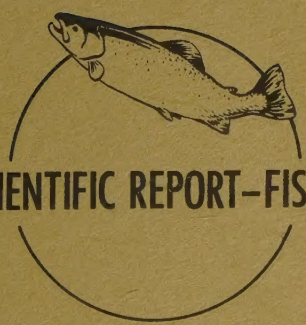
MID-PACIFIC OCEANOGRAPHY
Part VI, Hawaiian Offshore Waters, December 1949-November 1951



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Explanatory Note

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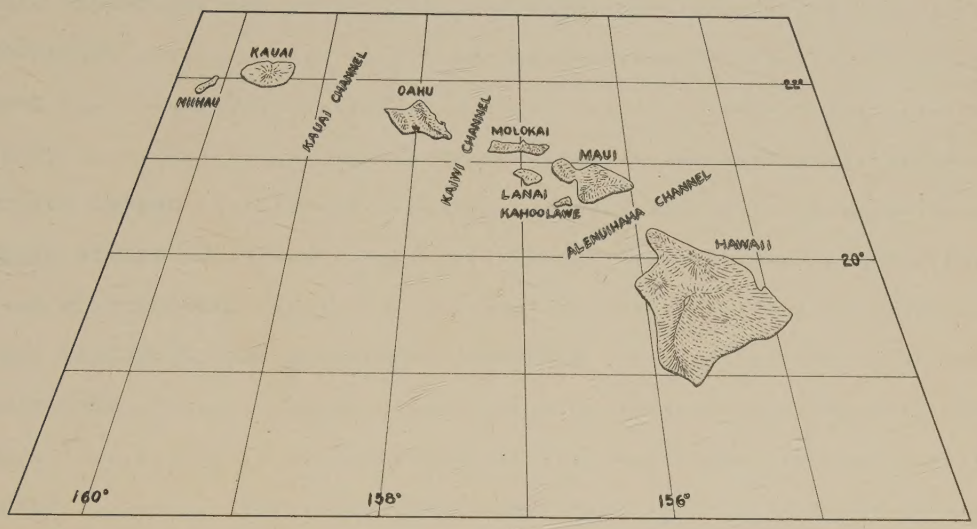

MID-PACIFIC OCEANOGRAPHY, PART VI

HAWAIIAN OFFSHORE WATERS

DECEMBER 1949-NOVEMBER 1951

By

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CONTENTS

	Page
Procedures	1
Hugh M. Smith cruise 1	8
General wind pattern	9
Dynamic topography and geostrophic currents	9
Temperatures	9
Sigma-t	10
Salinity	10
Dissolved oxygen	10
Hugh M. Smith cruise 10	11
General wind pattern	11
Dynamic topography and geostrophic currents	11
Temperatures	12
Sigma-t	12
Salinity	13
Dissolved oxygen	13
Hugh M. Smith cruise 12	13
General wind pattern	13
Dynamic topography and geostrophic currents	13
GEK currents	14
Temperatures	14
Sigma-t	14
Salinity	15
Inorganic phosphate	15
Discussion	15
Acknowledgements	18
Literature cited	19
List of figures	21
Figures 1-33	23
Remarks about the oceanographic data	56
Tabulated data, Hugh M. Smith cruise 1	57
Tabulated data, Hugh M. Smith cruise 10	75
Tabulated data, Hugh M. Smith cruise 12	109

This is the sixth of a series of descriptive reports on mid-Pacific oceanography by the Pacific Oceanic Fishery Investigations. The previous oceanographic reports presented and discussed data collected in the equatorial waters of the mid-Pacific.1/ The present report covers the data collected during the first three of a series of six general oceanographic cruises of the research vessel Hugh M. Smith in the waters adjacent to the Hawaiian Islands. The periods covered by the oceanographic phases of the cruises were: cruise 1, December 13-21, 1949; cruise 10, July 19-31, 1951; and cruise 12, October 23 to November 2, 1951.

The surveys of Hawaiian waters were initiated on the premise that the abundance and movements of the skipjack, Katsuwonus pelamis (Linnaeus), which forms the basis for the principal fishery of the islands, are controlled by events in the sea (Sette et al. 1954). The skipjack catches of the local fleet were used as a guide in planning the geographical and seasonal coverage of cruises 10 and 12. Cruise 10 was made when the fishery was at the summer peak, and cruise 12 was made during the middle of the fall decline.

The observational programs of these cruises were designed to collect chemical, physical, and biological data which could be used to map the circulation pattern of the island waters. From the circulation pattern it was hoped to locate areas where enough vertical motion might occur to enrich the surface layers and increase biological activity. On each cruise observations of temperature and salinity suitable for computation of currents in the upper 1,000 m. were made as well as bathythermograph lowerings for details of the temperature structure in the upper 900 ft. (270 m.). Other observations varied from cruise to cruise. Analyses for dissolved oxygen, which together with determinations of temperature and salinity help in tracing the circulation of different water masses and in their discussion, were made on cruises 1 and 10. Observations of inorganic phosphate, which is useful as an indicator of areas where turbulence and upwelling are sufficient to carry nutrients from the deep water to the euphotic zone, were made on cruise 12. Collections of zooplankton, which serves to indicate areas of past enrichment, were made on cruises 10 and 12. A geomagnetic electrokinetograph (GEK) was used to make current measurements during cruise 12.

Since the primary purpose of this report is to present the processed data in a form that is usable to POFI biologists and others interested in the hydrography of the area, the discussion of the results is purely descriptive. The major features of the circulation pattern and the results of the various observations2/ are described separately for each cruise. In the final discussion the features recurrent from cruise to cruise are explained in terms of the effect the island chain has on the general oceanic circulation in the area. These features are then examined further for areas in which enrichment of the euphotic zone might occur.

PROCEDURES

The vessel equipment, sampling methods, and most of the procedures used in processing the basic data have been described in the earlier reports by Cromwell (1951 and 1954), Austin (1954), and Stroup (1954). Minor changes which were made in the construction of cross sections, and procedures used in the construction of lateral (on sigma-t surfaces) and horizontal plots and in preparing types of data not used in the previous reports are described below.

A slightly different procedure was used in the preparation of the salinity, dissolved oxygen, and inorganic phosphate profiles. In the previous reports, which were concerned primarily with meridional aspects, the principle of drawing

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1/ Mid-Pacific Oceanography, Transequatorial Waters, Part I, Cromwell (1952); Part II, Cromwell (1954); Part III, Austin (1954); Part IV, Stroup (1954); Part V, Austin (1954).

2/ Except for zooplankton, which was the subject of a separate report by King and Hida (1954).

sections so that there was consistency among the various fields was maintained as rigidly as possible (Montgomery 1954). The station plots of each variable were drawn against temperature and their final shapes were determined by comparing them with the curves of the adjoining stations in the sections (Stroup 1954). In constructing the profiles the isopleth intervals were read from these plots, but their final shape was determined by placing the profiles over the sigma-t surfaces and then, with careful consideration of observed values, fairing them in as nearly parallel to the sigma-t isopleths as practicable. In this report, however, all surrounding stations were considered in constructing each of the station curves, so greater consideration was given to the interpolated isopleth intervals.

The values used in constructing the horizontal and lateral plots of dynamic topography, temperature, salinity, and sigma-t were interpolated from the individual station plots. Whenever it was possible, the spacing of the isolines on these plots was determined from the cross sections.

The topography of the sigma-t surfaces was drawn on the assumption that the major components of the subsurface flow are isentropic (along surfaces of equal potential density). The topography of four surfaces is shown for each cruise. The lowest valued surface varied from cruise to cruise and in each case was selected to depict the conditions at the lower limit of the quasi-homogeneous surface layer. The 24.0, 25.0, and 26.0 surfaces were selected as standard intervals to show the changes in topography and conditions between the surface and the intermediate water. When the variance of the salinity on these surfaces was great enough to be of value in tracing the circulation, the salinity contours were superimposed.

Instead of using the dynamic height[3] cross sections to compute velocities normal to the sections, as was done along the meridional sections described in the previous reports, dynamic height cross sections were used to construct plots of the geopotential topography[4] for the 0-, 50-, 100-, 200-, and 300-decibar surfaces. The spacing of the contours indicates the velocity relative to the 1,000-decibar surface.

Only a single geostrophic velocity scale is shown for each of the horizontal plots of geopotential topography. The velocities were computed for 20°N. latitude using the tables and formula given in H. O. 614 (Lafond 1951). This, taking into consideration the latitudinal difference, results in an apparent error of + 12 percent at the northern limits of the area (23°N.) and of -10 percent at the southern limit (18°N.). Considered alone, these appear to be errors of significant magnitude, however, if the indeterminable errors in direction and magnitude that could be caused by internal waves and topographical complications are also considered, the mean velocity diagrams become more acceptable. Seiwell (1937) found that internal waves would cause fluctuations in dynamic height of 14 cm. per day. Defant (1950) found that apparent eddies appeared in the data for the coastal waters of California if allowances were not made for internal waves. In the waters treated in this study the proximity to land and the bottom topography would also cause deviation of the actual currents from those indicated by the dynamic topography (Parr 1936).

In order to provide a general picture of the expected incident winds and currents for the cruise periods, monthly summaries of ships' reports of observed winds and currents have been prepared for the area east of (upstream from) the

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3/ The dynamic height is used in oceanography to express the vertical distance in gravitational potential between points in a selected isobaric (pressure) surface and a reference surface where the pressure field and the gravitational field are assumed to coincide. It is usually expressed in dynamic meters, which represents the work performed when a unit mass is lifted approximately 1 m. (.98 m. at sea level) against the force of gravity.

4/ The geopotential (dynamic) topography of the isobaric surfaces is simply a plot of the contours of equal dynamic height. The contours represent the lines along which a body can be moved without work being performed against the force of gravity.

Hawaiian Islands. The wind data (table 1) were based on the U. S. Navy Hydrographic Office Pilot Charts (H. O. 1401) and give the mean force and the percentage of the ships' wind observations that were reported for each cardinal and intercardinal point. The percentages were computed by averaging the values for the 5° squares between 15°N. and 25°N. latitude at 150°W. to 155°W. longitude.

Table 1.--Average force (Beaufort) of the wind and percentage of ship's observations reported from each of the cardinal and intercardinal points of the compass in the area east of the Hawaiian Islands. (H. O. 1401)

Direction	January		February		March		April		May	
	Ave. force	Per-cent	Ave. force	Per-cent	Ave. force	Per-cent	Ave. force	Per-cent	Ave. force	Per-cent
N	3-4	5	4	4	4	5	4-5	6	3	3
NE	4	29	4	40	4	40	4	46	4	52
E	3-4	42	3-4	34	4	28	4	35	3-4	34
SE	3	8	3	9	2-3	9	3	6	3	4
S	3	4	3	6	3	8	-	< 2	3	2
SW	3	2	3	3	4	4	-	< 2	-	< 2
W	4	4	4	2	4-5	3	-	< 2	-	< 2
NW	4	4	3	2	3	3	-	< 2	3	2
Calm	-	2	-	< 2	-	< 2	-	< 2	-	< 2

Direction	June		July		August		September		October	
	Ave. force	Per-cent	Ave. force	Per-cent	Ave. force	Per-cent	Ave. force	Per-cent	Ave. force	Per-cent
N	-	< 2	3	2	4	4	3	2	4	3
NE	4	54	4	64	4	56	3-4	56	4	47
E	3	37	3	30	3	34	3-4	33	3-4	38
SE	3	4	3	2	3-4	5	3	3	4	6
S	-	< 2	-	< 2	-	< 2	-	< 2	3	2
SW	-	< 2	-	< 2	-	< 2	-	< 2	-	< 2
W	-	< 2	-	< 2	-	< 2	-	< 2	-	< 2
NW	-	< 2	-	< 2	-	< 2	-	< 2	-	< 2
Calm	-	< 2	-	< 2	-	< 2	-	< 2	-	< 2

Direction	November		December		Annual average percent
	Ave. force	Per-cent	Ave. force	Per-cent	
N	4	5	4-5	6	4
NE	4	47	4	40	48
E	3-4	29	3-4	30	34
SE	3	10	4	10	6
S	3	3	3	6	3
SW	3-4	2	2-3	2	< 2
W	2	2	-	< 2	< 2
NW	-	< 2	3	3	< 2
Calm	-	< 2	-	< 2	< 2

The monthly current data (table 2) were computed from the U. S. Navy Hydrographic Office Current Atlas of the Northeastern Pacific (H. O. 570) in the same manner as the monthly wind data. The velocities are given in increments of 0.33 knots, which probably represents the limit of accuracy of the ships' observations on which they are based. At the foot of each monthly column is a mean direction for the month which has been taken from the current arrows given on the Pilot Charts (H. O. 1401).

Table 2.--Average velocity of the drift and the percentage of ship's observation reported towards each of the cardinal and intercardinal points of the compass in the area east of the Hawaiian Islands computed from data given in the Atlas of Surface Currents of the Northeastern Pacific (H. O. 570). Average drift was taken from H. O. 1401

Direction	January		February		March		April	
	Average velocity	Percent	Average velocity	Percent	Average velocity	Percent	Average velocity	Percent
N	0.34-0.66	10	0.34-0.66	11	0.34-0.66	13	0.00-0.66	11
NE	0.00-0.66	8	0.34-0.66	11	0.00-0.66	8	0.00-0.66	8
E	0.34-0.66	6	0.34-0.66	5	-	< 5	-	< 5
SE	0.00-0.66	7	0.34-0.66	7	-	< 5	-	< 5
S	-	< 5	0.00-0.99	9	-	< 5	0.00-0.66	9
SW	0.34-0.66	12	0.00-0.66	18	0.34-0.66	15	0.34-0.66	8
W	0.34-0.66	28	0.34-0.66	21	0.34-0.66	33	0.34-0.66	38
NW	0.34-0.66	18	0.34-0.99	15	0.34-0.66	15	0.34-0.66	17
Nil	-		-	< 5	-	6	-	< 5
Ave. ^{o}T	310		305		300		300	

Direction	May		June		July		August	
	Average velocity	Percent	Average velocity	Percent	Average velocity	Percent	Average velocity	Percent
N	-	< 5	0.00-0.66	13	0.34-0.66	10	0.34-0.66	12
NE	0.34-0.66	5	0.34-0.66	9	0.34-0.66	5	-	< 5
E	-	< 5	-	< 5	-	< 5	-	< 5
SE	-	< 5	-	< 5	-	< 5	-	< 5
S	-	< 5	-	< 5	-	< 5	-	< 5
SW	0.34-0.66	17	0.34-0.66	13	0.34-0.66	10	0.34-0.66	14
W	0.34-0.66	44	0.34-0.66	35	0.34-0.66	38	0.34-0.66	32
NW	0.34-0.99	13	0.34-0.66	19	0.34-0.66	20	0.34-0.66	20
Nil	-	6	-	5	0.34-0.66	7	0.34-0.66	6
Ave. ^{o}T	280		295		295		295	

Direction	September		October		November		December		Annual average percent
	Average velocity	Percent	Average velocity	Percent	Average velocity	Percent	Average velocity	Percent	
N	0.34-0.66	11	0.34-0.66	10	0.00-0.66	10	0.00-0.66	7	10
NE	0.34-0.66	5	0.34-0.66	8	-	< 5	-	< 5	9
E	-	< 5	-	< 5	0.34-0.66	6	0.34-0.66	5	< 5
SE	-	< 5	0.00-0.33	8	-	< 5	-	< 5	< 5
S	-	< 5	-	< 5	-	< 5	-	< 5	< 5
SW	0.34-0.66	10	0.34-0.66	15	0.34-0.66	21	0.34-0.66	16	14
W	0.34-0.66	38	0.34-0.66	34	0.34-0.66	32	0.34-0.99	36	34
NW	0.34-0.66	20	0.34-0.66	19	0.34-0.66	12	0.00-0.66	18	17
Nil	0.34-0.66	6	-	6	0.34-0.66	9	-	6	6
Ave. ^{o}T	260		280		270		290		

To show the short-period fluctuations in the currents incident to the islands that could have been expected if the effect of the wind were assumed to be instantaneous, tables of daily wind and current (tables 3-5) were computed for the week preceding and for the period of the cruises. The choice of the 1-week period before the cruise was purely arbitrary, and the data are merely included as background. The winds were computed from the pressure gradients indicated by the U. S. Weather Bureau Synoptic Weather Maps and in turn were used to compute the currents.

A point at 20°N. latitude, 155°W. longitude was selected as a standard reference because the majority of the winds were easterly. Inspection of the charts indicated that one value per day is sufficient to reflect the major changes in the pressure pattern, so only the 1200Z charts were used.

Table 3.--Cruise 1, computed surface winds and currents at 20°N. and 155°W. Winds were computed from 1200Z, U. S. Weather Bureau Synoptic Charts by the method described in U. S. Navy Hydrographic Office Miscellaneous Publication 11,275. Currents were computed by Ekman's formulae

Date	Wind Dir. °T	Wind velocity kt.	Wind fetch miles	Current Dir. °T	Current velocity kt.	Remarks
12-7-49	090	14	1200	315	.3	
12-8-49	145	11	480	010	.2	Low centered at 23°N.-169°W.
12-9-49	120	15	390	345	.3	Low centered at 24°N.-164°W.
12-10-49	115	17	510	340	.4	Stationary front 20°N.-160°W. to 17½°N.-165°W.
12-11-49	120	13	470	345	.3	
12-12-49	105	13	650	330	.3	
12-13-49	090	25	1450	315	.5	
12-14-49	075	20	750	300	.4	
12-15-49	120	11	560	345	.2	Low centered at 29°N.-164°W.
12-16-49	120	18	600	345	.4	Low centered at 29°N.-167°W.
12-17-49	120	15	500	345	.3	Shallow trough along 165°W.
12-18-49	110	9	900	335	.2	Shallow trough along 160°W.
12-19-49	110	9	600	335	.2	Low forming over the islands.
12-20-49	-	-	-	-	-	Trough over the islands well developed trade winds east of the islands.
12-21-49	-	-	-	-	-	

The wind velocities were obtained by first computing the geostrophic wind from the weather charts and then multiplying it by a reduction factor which took into account the curvature of the isobars (H. O. Misc. Pub. 11,275). Most of the time the islands were under the influence of the Eastern North Pacific High, and, as indicated by the large fetches, the isobars had little curvature, so 0.67, the value for isobars of small anti-cyclonic curvature, was used. During the periods when lows or troughs were over the islands 0.60, the factor for isobars of great cyclonic curvature, was used. Whenever possible, the reliability of these computed

values was checked by comparing them with ships' observations. With few exceptions, the difference was not more than one force of the Beaufort scale or one compass point, which are considered satisfactory checks.

Table 4.--Cruise 10, computed surface winds and currents at 20°N., 155°W. Winds were computed from the 1200Z, U. S. Weather Bureau Synoptic Charts by the method described in the U. S. Hydrographic Office Miscellaneous Publication 11,275. Currents were computed by Ekman's formulae

Date	Wind Dir. °T	Wind velocity kt.	Wind fetch miles	Current Dir. °T	Current velocity kt.	Remarks
7-9-51	095	9	490	320	.2	
7-10-51	080	13	960	315	.3	
7-11-51	095	17	600	320	.4	
7-12-51	090	13	810	315	.3	
7-13-51	085	20	900	310	.4	
7-14-51	080	13	1150	305	.3	
7-15-51	110	10	1300	335	.2	
7-16-51	075	13	150	300	.3	Wave in isobars E. of the islands.
7-17-51	080	13	600	305	.3	
7-18-51	100	14	600	325	.3	
7-19-51	090	18	750	315	.4	
7-20-51	120	13	300	345	.3	Wave in isobars W. of the islands.
7-21-51	090	15	1150	315	.3	
7-22-51	105	17	1250	330	.4	
7-23-51	105	15	750	330	.3	
7-24-51	095	14	750	320	.3	
7-25-51	095	14	650	320	.3	
7-26-51	090	13	850	315	.3	
7-27-51	090	14	1250	315	.3	
7-28-51	080	13	1100	305	.3	
7-29-51	090	13	1100	315	.3	
7-30-51	105	10	600	330	.2	
7-31-51	100	13	550	325	.3	

Table 5.--Cruise 12, computed surface winds and currents at 20°N., 155°W. Winds were computed from the 1200Z U. S. Weather Bureau Synoptic Charts by the method described in the U. S. Hydrographic Office Miscellaneous Publication 11,275. Currents were computed by Ekman's formulae

Date	Wind Dir. °T	Wind velocity kt.	Wind fetch miles	Current Dir. °T	Current velocity kt.	Remarks
10-13-51	075	9	1050	300	.2	
10-14-51	090	11	800	315	.2	
10-15-51	095	14	600	320	.3	
10-16-51	125	10	500	350	.2	
10-17-51	115	10	500	340	.2	
10-18-51	120	11	450	345	.2	
10-19-51	100	14	500	325	.3	
10-20-51	100	14	800	325	.3	
10-21-51	090	11	750	315	.2	
10-22-51	070	14	650	295	.3	
10-23-51	080	14	750	305	.3	
10-24-51	095	13	1250	320	.3	
10-25-51	105	10	1100	330	.2	
10-26-51	120	11	500	345	.2	
10-27-51	130	8	600	355	.2	Low at 25°N.-157°W.
10-28-51	170	9	300	035	.2	Low at 26°N.-163°W.
10-29-51	150	13	500	015	.3	Low at 27°N.-161°W.
10-30-51	150	9	500	015	.2	Trough along 163°W.
10-31-51	-	-	-	-	-	Small trough over the Hawaiian Islands.
11-1-51	170	9	100	035	.2	Deep trough over the Hawaiian Islands. Front 30 miles north of Kauai.

The fetch was computed and included as an index to the extent of the wind field. It was the distance between 20°N., 150°W. and the point where the curvature of the isobars increased until they made an angle greater than 30° with their direction at 20°N., 150°W.

The wind direction was obtained by applying the rule that outside the tropics in the Northern Hemisphere the wind over the ocean deviates 80° to the right of the pressure gradient.

The ocean current velocities and directions were computed from the wind data using the empirical relationships derived by Ekman (Sverdrup et al. 1946, p. 494) and assuming that the wind forces acted instantaneously. The formula used to compute the velocities was

$$\frac{v}{W} = \frac{0.0127}{\sqrt{\sin \varphi}}$$

where v = current velocity, W = wind velocity, and φ = latitude. The direction was obtained by applying the rule that the current is directed 45° to the right of the wind in the Northern Hemisphere.

During cruise 12 surface or near-surface current measurements were made with the von Arx (1950) GEK. The current vectors were corrected for the error due to the difference in depth (droop) of the two electrodes. This correction consisted of a vector directed towards the magnetic Equator. The magnitude of this vector was dependent upon the ship's speed, the direction of the ship's motion, and the amount of droop, and was computed by means of formulae derived by John Knauss (personal communication).2/

HUGH M. SMITH CRUISE 1

Cruise 1 of the Hugh M. Smith was planned primarily as a shakedown cruise for the vessel, gear, and personnel. Therefore, the station pattern was designed to take advantage of the lee provided by the island of Hawaii. Figure 1 is a chart of the station positions. The solid lines indicate the lines along which cross sections of bathythermograph temperatures (°F), sigma-t, salinity (°/oo), and dynamic topography (m.) have been drawn. Stations 8A and 8B were occupied several days before adjoining stations in the regular series, so their data were not used in the analyses but are included in the tabulated data.

Since the discussion of the various fields of a water mass is more understandable when the general character of the flow pattern has been established, the usual procedure of presenting the results of the cruises is reversed in this report. The winds and computed currents are discussed first. This is followed by the dynamic topography and the geostrophic currents. Then the fields of temperature, density, salinity, and dissolved oxygen are presented in the order named.

2/ The magnitude of the droop was calculated from observations made at the earth's magnetic equator on a later cruise. The formula used was

$$D = \frac{v_c}{v_s} \frac{H_s}{H_l} S$$

where D = droop
S = distance between electrodes
v_c = resultant signal vector
v_s = speed of the ship
H_h = horizontal magnetic field component
H_s = magnetic field component set on the GEK.

Using the computed values of D, the magnitudes of the corrective vectors were then computed by the formula,

$$\bar{v} = \bar{v}_t - v_s \frac{D}{S} \frac{H_h}{H_s} \bar{u}$$

where
$\bar{v}$ = true current
v_t = current calculated
u = unit vector in the opposite direction of H_h in the Northern Hemisphere and the same direction in the southern.

General Wind Pattern

The wind pattern (table 3) over the islands was influenced by two low pressure systems which developed in the area to the west. The first, December 7 to 10, did not pass over the islands. The second, which first appeared on the U. S. Weather Bureau map of December 15, moved in over the islands and persisted until the end of the cruise. As a result of these lows, the winds were more southerly than normal for December (table 1). When they are transformed into current direction by the 45° *cum sole* rule, the inferred currents are 10° to 80° to the right of the 290°T average indicated by the Pilot Chart.

As mentioned above, during the process of checking the reliability of the winds computed from the synoptic charts (USWB) these winds were compared to the observed winds recorded in the bathythermograph logs. The results were rather startling and it at first appeared that the computed winds were unreliable. However, because of excellent agreement between computed and observed winds in the upwind area and the fact that almost all of the BT observations were in the lee of Hawaii, it has been suggested that the variance was the result of the "barrier" effect of the high mountains of the island (Saul Price, USWB, personal communication). Data from this and subsequent cruises are now being analyzed to determine the nature of the effect.

Dynamic Topography and Geostrophic Currents

The dynamic heights are shown in figure 2 and the geopotential topograph in figure 3. The dotted lines in the vicinity of station 1 represent extrapolated values necessary because of bottle failures below 600 m. at station 1 and are intended merely to indicate the direction of flow. The heights are based on the rather dubious assumption that the height of the 700-decibar (m.) surface at station 1 is the mean of the heights at stations 2 and 8. This method was used because the extrapolated values of salinity and temperature at station 1 provided extremely large dynamic heights, indicating currents of up to 1.8 knots in the surface layers. The actual currents were probably somewhere between those indicated by the contour in the figures and those indicated by the extrapolated temperatures and salinities.

The geopotential topography shows an extremely well-developed cyclonic[6/] eddy. At the surface it was centered at station 6, but it shifted towards the island with depth, being centered at station 7 below the 100-decibar surface. The cross sections (fig. 2, panel B) show that it was still evident down to the 500-decibar surface at station 7.

The most striking feature of the velocity field was the persistence of the surface velocities down to the 300-decibar surface in the southern part of the eddy. The velocities at the surface were almost uniform, except for slight maxima of about 0.8 knots (40 cm/sec) between stations 11 and 14. The velocities around the eddy decreased with depth, as expected, except in the vicinity of station 2, where velocities of 0.7 knot (35 cm/sec) were still indicated at the 300-decibar surface.

Temperatures

The temperature cross sections (fig. 4) were constructed from bathytherm graph observations.

The general distribution of temperature followed the pattern that was in ferred from the geostrophic currents, i.e., the isotherms show doming in the cente

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6/ In the northern hemisphere, flow which curves to the left (counterclockwise), when facing downstream, is cyclonic, and flow which curves to the right (clockwise) is anti-cyclonic (Holmboe et al. 1946, p. 191). A cyclonic eddy is characterized by a depression in the geopotential topography at its center, and an anti-cyclonic eddy by a doming.

of the eddy (fig. 4, panels B and C). A strong northerly flow is indicated by the depth and sharpness of the thermocline along the southwest coast of Hawaii.

The effects of diurnal heating were shown by the small pockets of warm water on the surface at stations 6, 10, and 14. In each case the BT lowerings were made during daylight and when the wind was Beaufort force 2 or less.

In order to estimate the amplitude of internal waves that could be expected in the area, the vessel was permitted to drift from 1930Z December 12 to 1000Z December 13 at approximately 19°41'N., 156°15'W., while bathythermograph lowerings were made at half-hour intervals. As was expected (Sverdrup et al. 1946, p. 588), the results (fig. 5) show that the amplitude was greatest at the top of the thermocline and decreased rapidly with depth. The 75°F. isotherm, which was just below the thermocline, had a maximum change of depth of 115 feet, while the 60°F. isotherm had a change of only 80 feet. Although the data indicate the presence of waves of several periods, the time covered by the observations was too brief to permit further analysis of the data.

Sigma-t

The distribution of sigma-t, as shown by the cross sections (fig. 6) and lateral surfaces (fig. 7) is consistent with the dynamic topography. The cyclonic nature of the eddy is shown by the doming of the isopleths in the vicinity of station 6.

The topography of the 23.6, 24.0, 25.0, and 26.0 surfaces indicates that the source of most of the water in the eddy was from flow around the southern coast of Hawaii. Flow through Alenuihaha Channel is not indicated until the depth of the 25.0 and 26.0 surfaces is reached and then it is relatively weak.

The 23.6 surface was selected for contouring because it was the greatest value that intersected the surface and therefore should illustrate the greatest depth from which nutrients could be brought to the surface by isentropic flow. However, since the difference in density is greater than the difference in temperature on the two sides of the eddy would indicate, it is probably indicative of the degree of intrusion of less saline water that was being driven into the area around the southern tip of Hawaii by the southeasterly winds which predominated during the cruise period.

Salinity

The salinity cross sections (fig. 8), surface salinity (fig. 9), and plots of salinity on the sigma-t surfaces (fig. 7) show the degree of the intrusion of water from the southeast. The surface salinities show that water having a salinity of less than 35.0 °/oo had entered between stations 1 and 2 and had penetrated three-quarters of the way around the eddy. Below the surface its progress is shown by the trough of low salinity on the 24.0 sigma-t surface and by the tongue of low salinity water that had penetrated to station 9 on the 25.0 surface.

Dissolved Oxygen

The vertical distribution of dissolved oxygen (fig. 10) is very similar to that shown for 20°N. latitude in the Carnegie section (Sverdrup et al. 1946, p. 710) except for the O_2 maximum of greater than 5.0 ml/l. The Carnegie data show that this corresponds to the S °/oo maximum, and hence it can be attributed to contact with the atmosphere in the region northeast of the islands, where evaporation and cooling caused the surface waters to sink and spread out as an intermediate layer. In figure 10 it is present only as a small elongated cell at about 100 m. on an axis through stations 2 and 15 and corresponds to the trough of low salinity which appeared on the 23.6 and 24.0 sigma-t surfaces.

HUGH M. SMITH CRUISE 10

Cruise 10 of the Hugh M. Smith, July 19-31, 1951, was the first of a series of five cruises to investigate the general hydrographic conditions in the offshore waters of the Hawaiian Islands. Thirty-three stations were occupied at the positions shown in figure 11. Casts to 1,200 m. were made at all stations except 15, 16, 20, and 21, where casts were made to approximately 50 m. above the bottom. Stations 19 and 33 were occupied at approximately the same position. The data from the two were averaged in constructing the station plots, since both fitted into the time sequence when compared to adjacent stations. Stations 8A and 8 were also occupied at approximately the same position, but in this case the time interval between 8 and all the surrounding stations was less than for 8A so only 8 was used.

The solid lines on the station plot (fig. 11) indicate the lines along which profiles of dynamic height, temperature, sigma-t, salinity, and dissolved oxygen have been drawn.

The order and method of presenting the data are the same as for cruise 1.

General Wind Pattern

The weather maps for the cruise period show the well-developed Eastern North Pacific High which is typical of summer conditions. However, comparison of the computed winds (table 4) with the average winds (table 1) shows that the forces were normal for July but that an abnormally large percentage of observed winds were from the east. The computed velocities vary from 9 to 20 knots, with 16 of the 23 values being within the 11-16 knot range of the Beaufort 4 average for the month. Out of 23 observations, 16 or 70 percent show east winds, although the normal for the month is only 30 percent. When the wind directions were transformed into current direction by the 45° *cum sole* rule, they were 5° to 50° to the right of the 295°T mean for July (table 2).

Dynamic Topography and Geostrophic Currents

The dynamic height cross sections are shown in figure 12 and the dynamic topography of the upper 300 decibars (m.) in figure 13. Because of uncertainty as to the effect of land masses on the topography, no attempt was made to construct the topography inshore of stations, except in areas where there were strong indications that the flow should follow a definite pattern because of the physical configuration of the land masses and the circulation in the surrounding area. For example, the contours were drawn in the area south of Hawaii because the topography to the east and south indicates a strong flow parallel to the south coast of that island due to the divergent effect of the island barrier. In this and similar cases the contours are dotted.

The topography shows that the circulation on the northeast or windward side and on the southwest or leeward side of the island chain is completely different. On the windward side of the islands the circulation was quite confused (figs. 12 and 13). The flow was westerly all along the section from station 27 to station 30, with the highest velocities occurring between stations 27 and 28. The flow between stations 30 and 32 was easterly, but it turned again to the west north of station 32. In the area north of Oahu the flow was deflected northwestward along the islands.

On the leeward side two large cyclonic eddies dominated the circulation pattern (figs. 12 and 13), one centered at station 23 and the other at station 10. The one west of Hawaii, centered at station 23, was much farther north than during cruise 1. The slopes of the surfaces in the eddy centered at station 10 were so great that it seems reasonable to assume that it was a case where external effects such as tides or internal waves were in phase with the effect of the horizontal motion.

Kauai Channel is the only channel for which there are sufficient data to attempt to contour the topography. The resulting flow pattern is very confused. The heights of the surfaces at station 8 indicate northerly or clockwise flow around the west coast of Oahu. On the Kauai side of the channel northerly flow is indicated by the 0-, 50-, and 100-decibar surfaces and westerly by the 200-decibar surface.

Temperatures

The temperature data are again based on the bathythermograms. Figure 14 shows the temperature profiles for the five sections indicated on the track chart. Figure 15 is a plot of the depth of the 75°F. isotherm, which was drawn as an example of a rapid field method for obtaining the major features of the circulation pattern.

Over most of the area the basic configurations of the temperature field followed the pattern expected from the geostrophic flow. For example, both the cross sections and the plot of the depth of the 75°F. isotherm show a doming of the subsurface isotherms at stations 10 and 23.

The temperature field in Kauai Channel differed in some respects from that expected from the geostrophic currents. At station 3, where the isotherms dome, there was mixing, caused by divergence or wind stirring, strong enough to lower the surface temperature. The plot of the 75°F. isotherm indicates that it was part of a cold dome extending northeastward to the area between stations 6 and 7. The cyclonic circulation required to produce this condition agrees with the northerly geostrophic currents at the surface on the Oahu side of the channel but not with those on the Kauai side.

As a result of summer heating, the temperature of the surface layers in the area west of Hawaii were at least 1° to 2°F. higher than those of cruise 1. The effects of local heating are shown in the cross sections by the small cells of water at the surface having a temperature higher than 79°F.

Sigma-t

The effect of summer heating on the density is shown on the cross sections by the lower density of the approximate boundary between the quasi-homogeneous surface layer and the well-defined density gradient. At the time of the winter cruise (cruise 1) the boundary was the 23.8 surface, but on this cruise it was only the 23.2 surface.

In the surface layers (fig. 17), two features stand out in the complicated circulation pattern. The first is the band of surface water with sigma-t greater than 23.0 on the northeast side of the islands. It was not related to the current pattern but was a combination of the high salinity around station 31 and the low temperatures along the islands (bucket and reversing thermometer temperatures). The second was the low values, as low as 22.65 which occurred over the surface of the eddy west of Hawaii. They were due to high surface temperatures which persisted in spite of the force 5 winds reported in the bathythermograph log.

The horizontal plots of depth of sigma-t surfaces (fig. 18) have the topography indicated by the geostrophic currents. They are included only for the detail they add in the area north of the middle group of islands. The 25.0 and 26.0 contours show that the incident currents separated north of Molokai, one branch turning northwest along the islands, and the other turning cyclonically away from the islands, thus completing the pattern shown by the geostrophic currents.

Salinity

The salinity cross sections (fig. 19) show a maximum greater than 35 °/oo just below the quasi-homogeneous surface layer at all stations except 22. However, the Nansen bottle spacing was such that this layer was missed in the sampling at a large number of stations, so it was largely constructed by reference to the T-S diagrams of the adjoining stations. The thickness of the layer was greatest in the western section (fig. 19, panel A), where the > 35.0 °/oo band was 100 m. or more in thickness.

The surface salinity (fig. 20) reflects the extent of the sub-surface maximum by sharp increases in the west and northwest sectors. Over the rest of the area it is almost uniform (34.6 - 34.7 °/oo), except for the area around the middle islands, where a cell of less than 34.6 °/oo occurred, and around stations 10 and 31, where it increased sharply. The minimum could only have been caused by runoff from the islands. The maxima were in areas of strong cyclonic motion and could have been caused by divergence.

Dissolved Oxygen

The vertical distribution of dissolved oxygen (fig. 21) was typical of the North Pacific at these latitudes. It had a maximum of more than 5.0 g/l just below the level of the well-defined density gradient and a deep minimum of 0.6 - 1.0 ml/l at the 500-800 m. level. The maximum is attributed to contact with the surface at the subtropical convergence during the period when evaporation increased the salinity. Although the minimum is frequently attributed to lack of replenishment by horizontal flow, its origin is not completely understood.

HUGH M. SMITH CRUISE 12

Cruise 12 of the Hugh M. Smith was made to observe the hydrographic conditions in the offshore waters of the Hawaiian Islands during the period when the local skipjack fishery was undergoing its fall decline. The station coverage (fig. 22) was similar to cruise 10, but a number of changes were made in the observational program. Dissolved oxygen analyses were omitted and inorganic phosphate analyses were included. The geomagnetic electrokinetograph, which had been installed just before this cruise, was used to make current observations at each station and midway between stations. The stations north of Hawaii, 31 to 32 of cruise 10 (fig. 11), were omitted to permit further study of the eddy indicated in the vicinity of station 1 by the GEK data.

The order and method of presenting the data are the same as for cruises 1 and 10.

General Wind Pattern

The winds during the cruise period (table 5) were of about normal force for October, but they were more southeasterly than normal. From October 13 to 26 they were part of the circulation around the Eastern North Pacific High, but a greater percentage than normal were from the east and southeast. Therefore, the currents inferred by the 45° *cum sole* rule are 15° to 55° to the right of the 280°T mean for October. A shift of the currents even further to the right may be inferred after October 27, when the wind shifted to the south as a low moved into the area from the west.

Dynamic Topography and Geostrophic Currents

The dynamic heights (fig. 23) showed less variation than those of cruise 10 and consequently the geostrophic currents (fig. 24) were shallower and weaker. Significant velocities of 10 cm/sec (0.2 kt.) or greater were limited to depths of

300 m. or less, and at that level velocities of this magnitude were found only between stations 29 and 30. In contrast, during cruise 10 velocities of over 20 cm/sec (0.4 kt.) were found on the 300-decibar surface.

On the windward side of the islands the dynamic topography contours are incomplete because of the omission of the stations north of Hawaii. The flow normal to the section east of Hawaii was confused in the upper 150 m. by the easterly flow indicated between stations 28 and 29. North of Oahu the flow was again northerly, indicating that the major portion of the flow was being deflected by the middle group of islands.

To the leeward of the islands the most prominent features were again the two cyclonic eddies. The one west of Hawaii was larger in diameter, but did not have velocities as great as the corresponding eddy of cruise 10. The eddy south of Oahu was centered off station 1. It was also relatively weak, having a maximum velocity of only 30 cm/sec (0.6 kt.) as against the 72 cm/sec (1.4 kt.) maximum of cruise 10.

In Kauai Channel northerly flow was indicated in the upper 100 m. It was again the result of the high values at station 8, which were indicative of a clockwise flow around Oahu.

GEK Currents

The current vectors computed from GEK observations are shown in figure 25. They represent POFI's first attempt at direct current measurements in the Hawaiian area. The results are only partially satisfactory, if the surface geostrophic currents are used as the standard. They agree fairly well in direction and magnitude in the offshore areas where the velocities were large, such as in the leeward eddies, but in the vicinity of station 8, just west of Oahu, the GEK currents were southerly and the geostrophic northerly. As mentioned above, the accuracy of the latter are also open to doubt in inshore areas, but it is doubtful if the error could be over 90°, as the GEK currents would indicate.

The persistence of the eddy around station 1, shown by the "recheck" of the area, was the most interesting information provided by the GEK. In spite of time differences of up to 7 days and a shift of the incident winds from east to south, the observations made on the second coverage of the area (those marked "A" in fig. 25) agree almost perfectly with those made on the first.

Temperatures

Again the temperature field (figs. 26 and 27) was simply a reflection of the distribution of mass associated with the circulation pattern shown by the geostrophic currents. Divergence and/or wind-mixing in the eddy west of Hawaii was shown by the 2°F. drop in surface temperature at its center.

Sigma-t

The sigma-t distribution (figs. 28 and 29) differs only slightly from that of cruise 10. On the windward side, east of stations 17 and 18, the 23.2 sigma-t surface is still the upper limit of the well-defined density gradient, but over the rest of the area it is the 23.0 surface. The difference was caused by slightly lower surface temperatures in the southeastern sector of the windward side. This difference could be attributed directly to mixing or "upwelling" only in the area around station 19, where the 23.0 sigma-t isopleth reached the surface and surface salinity was slightly greater than in the surrounding area.

The horizontal plots of depth of sigma-t surfaces are again included for the information which the 25.0 and 26.0 surfaces add to the description of the circulation north of the middle group of islands. The cells of greater than 200 m. in

the 25.0 surface and of greater than 320 m. in the 26.0 surface are indicative of anti-cyclonic flow due to the deflective effect of the islands. In both cases the centers of the cells were closer to the islands than during cruise 10.

Salinity

A cell of high-salinity water in the well-defined density gradient was again the most prominent feature of the salinity cross sections (fig. 30). The upper 35.0 °/oo isohaline, which approximated its upper limit over the entire area except east and south of Hawaii and at stations 2 and 14, coincided approximately with the 24.0 sigma-t surface.

In the area east of Hawaii the salinity maximum was between 34.8 and 35.0 °/oo, indicating that water of lower salinity was moving into the area. The station plots indicate that it penetrated at least as far as station 26.

The surface salinities (fig. 31) were 0.1 to 0.2 °/oo higher than on cruise 10 except in the channel between Maui and Lanai, where a small cell of low-salinity water again indicated runoff, and in the section east of Hawaii, where the pattern was as confused as, and probably the result of, the current pattern (fig. 24). At station 29 there was a cell of low-salinity water at the surface which because of the easterly flow indicated by the geostrophic currents could be ascribed to the runoff from the windward coast of Hawaii. At the adjoining station (28) the cell with salinity greater than 34.8 °/oo broke the surface. Considered in conjunction with the dome in the 78.0°F. isotherm, this would indicate divergence in spite of the "high" in the dynamic topography.

Inorganic Phosphate

In the surface layers of the ocean there is a continual loss of the dissolved nutrient salts from the euphotic zone because of the production of organic material and a general downward movement of the particulate matter thus formed. In the open ocean the only processes by which nutrients can be returned to the surface layers are vertical diffusion, convective overturn, and divergence (upwelling). To determine whether mixing or divergence of sufficient magnitude to cause enrichment of the surface layers was induced by the complex flow around the islands, inorganic phosphate analyses were made during cruise 12. Phosphate analyses were made because they are more adaptable to shipboard work than those for nitrate, the other major dissolved nutrient salt.

Only the cross sections of inorganic phosphate (fig. 32) are included, since they are adequate to depict the variations. The 0.6-µg atoms/l isopleth formed the upper boundary of the well-defined gradient. It was between the 24.8 and 25.2 sigma-t surfaces and at a depth of 150 m. or greater, except at station 5, where it was at only 52 m. Although the 0.4-µg atoms/l surface has been drawn in, the distribution above the 0.6-µg atoms/l level was very irregular and bore little resemblance to the other features. This was probably because the lower limit of the accuracy of the method of analysis was being approached (Wooster and Rakestraw 1951).

DISCUSSION

The marked similarities of the circulation patterns of the three cruises have been pointed out repeatedly in the discussion of the results. These quasi-permanent features are more understandable if the nature of the island barrier and the incident currents are explained and their interaction discussed piecemeal.

The first impression given by the chart of the windward or high islands of the Hawaiian Archipelago is of a series of vertical obstacles lying in a southeast to northwest direction. However, when a cross section of the islands is constructed (fig. 33), they are seen to resemble a solid barrier having four small

openings. Only two of these openings, Kauai Channel between Oahu and Kauai, and Alenuihaha Channel between Hawaii and Maui, extend below the 1,000-m. depth that has been assumed as the level of no motion in the computation of dynamic heights. The third, Kaiwi Channel between Molokai and Oahu, has a sill depth of only 614 m. (336 fathoms). The fourth, between Molokai and Maui, is almost negligible; it is split by Lanai Island and has a sill depth of only 80 m. (44 fathoms) and a width of only 8 miles.

Sverdrup (1946, p. 723) states that "a clockwise rotating gyral is present in the eastern North Pacific with its center to the northeast of the Hawaiian Islands. It is probable that the location of this gyral changes with the seasons and shifts from year to year, so that occasionally the gyral may lie entirely to the northeast of the Hawaiian Islands, whereas in other circumstances the Hawaiian Islands may lie inside the gyral." This implies that the flow incident to the islands is either toward the west or slightly northwest. It may be further assumed that it is continually fluctuating, since the Eastern North Pacific High, which provides the driving force, varies constantly in intensity and position.

Further evidence of the seasonal variation in the incident currents and the variations in the incident currents which might be expected during a single month is shown by the charts of mean wind and mean currents (summarized in tables 1 and 2) for the area east of Hawaii. The average monthly current directions, which were taken from the Pilot Charts, illustrate the annual cycle. The most northerly average direction, 310°T, occurs in January, when the greatest percentage, 42 percent, of easterly winds was reported. The most westerly direction (260°T) occurs in September. This is also the period when the Eastern North Pacific High starts to decline in intensity, and this could account for the relatively weak flow of cruise 12. The greatest variation of both winds and currents occurs during the November to March period, when the Eastern North Pacific High is least developed. It is during this period that low pressure cells, such as those that were present during cruises 1 and 12, move into the island area bringing the "kona"[7] storms (Simpson 1952).

When the nature of the island profile and the westerly flow are considered, the quasi-permanent features can be ascribed to (1) a stream flow impinging upon a lamina at a shallow angle, (2) flow around a single barrier (Long 1952), (3) a jet or wake stream discharged into a fluid at rest (Rossby 1936), or (4) a combination of (2) and (3).

Although there was some flow through the channels, the middle group of islands (Oahu-Maui) seemed very much like a solid barrier, so that the circulation to the east resembled in many respects a "stream flow on a lamina" (Lamb 1932). In such a case, the flow is split by the barrier; the point of separation and the amount going in either direction are dependent upon the angle of impact. The incident flow of both cruises 10 and 12 was from an easterly direction, so that the major part of the flow was deflected to the right or northwest and only a small part to the left or southeast. The easterly flow southeast of station 32 during cruise 10 was the result of the segment of the incident current that was deflected to the left.

The angle of deflection or degree of anti-cyclonic motion imparted to the segment of the incident current that was deflected to the right controlled the flow through Kauai Channel during cruises 10 and 12. During cruise 12, when the geostrophic currents north of Oahu had a strong northerly component, the flow was northerly through the channel. During cruise 10, when the angle of deflection was small at the surface and decreased still further with depth, the flow was across the channel above the 200-decibar surface, where a slight westerly flow was indicated.

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[7] Kona, a Polynesian adjective meaning "leeward," is used locally to describe periods during which the usually persistent tradewinds are replaced by southerly winds and rain squalls. Each year the drier leeward sides of the Hawaiian Islands receive more than half of their rainfall from two or three of these storms.

In the lee of the islands there was a striking resemblance between many of the features of the flow pattern and the "east wind case" described by Long (1952) in his discussion of the results of model studies of flow past a barrier in a rotating spherical shell. This was particularly noticeable in the results of cruise 1, which had the stations most closely spaced and a series close inshore. On the equatorward side Long found that the fluid in the immediate vicinity of the barrier curved northward along the obstacle for about a quadrant (90°) while the bulk of the fluid continued in a general westerly direction. This phenomenon could account for the strong northerly flow along Hawaii during cruise 1 and the greater dynamic height at station 8 during both cruises 10 and 12. Along the boundary between the bulk of the fluid that was continuing westward and the wake of the barrier he found a series of horizontal clockwise eddies having their axes directed easterly. He attached no significance to their direction and doubted that they could exist in a stratified fluid such as the ocean. However, it is felt that the persistence of the easterly flow down to the 300-decibar surface on cruise 1 is a manifestation of this phenomenon.

On the poleward side he found that the flow separated from the barrier and moved zonally to form a series of cyclonic eddies. This would suggest that the eddies found in the survey area are merely the first of a series that occur downstream from the islands. However, it must be remembered that only part of the incident flow passes through the channels, so that a complete analogy to the single barrier case is not valid.

It has been demonstrated that a similar series of eddies would result from the flow through the channels. Rossby (1936) showed in his Wake Stream Theory that as a jet or wake, which has been discharged into a fluid at rest, passes downstream it acts as a series of sinks with respect to the surrounding fluid. Large quantities of fluid are removed from the surroundings, and this removal is associated with the creation of a countercurrent along the left side. The mass transport increases downstream, but is intermittently reduced through the discharge of eddies along the boundary of the currents. On the right side a compensation is set up which decreases in intensity and becomes negligible. Thus, the eddy west of Hawaii can be attributed to the flow through Alenuihaha Channel and the one west of Oahu to the flow through Kauai Channel. Again minor discrepancies between the selected model and prototype are evident. In the first case it has already been shown that during cruise 1 part of the flow was the result of the clockwise flow around the island of Hawaii. In the second case the magnitude and strength of the eddy, particularly during cruise 10, seemed larger than could be expected from such a limited source as Kaiwi Channel.

The variations in strength, magnitude, and position of the eddies during the three cruises reflect the varying direction and strength of the incident currents which were inferred from the monthly wind and current data. However, the stability of the eddy south of Oahu, as shown by GEK observations made as much as 1 week apart and after a 90° shift in the incident winds, indicates that these changes must occur very gradually.

When the sigma-t cross sections are compared to the inorganic phosphate cross sections of cruise 12 (fig. 32) to determine whether enrichment of the surface layers by lateral mixing (along sigma-t surfaces) occurred in the eddies or in any other areas, the results are insignificant compared to those reported for equatorial waters by Cromwell (1951) and Austin (1954). The greatest depth from which nutrients could have reached the surface by lateral mixing during any of the cruises was about 100 m., i.e., at stations 12 and 14 during cruise 1 (fig. 6, panels C and D) or at stations 1 and 25 during cruise 10 (fig. 16, panels A and D). Such mixing could not have produced much enrichment, because the phosphate-rich layer was below 150-200 m. during cruise 12.

The great depth of the phosphate-poor layer in the Hawaiian Island area can be explained by the circulation which produced the high-salinity water that lies at its lower limit. This layer is the result of subsidence and spreading out of water which has had its density increased by evaporation and cooling as it moved

around the Northeast Pacific Gyral. Sverdrup (1946, fig. 209A), indicated that the source of this water is at about 40°N., 140°W. This results in a sub-surface recirculation over the area of water that is already low in inorganic phosphate. The acceleration of the natural tendency for organic phosphate to settle out as particulate matter by the downward motion in the area of subsidence would also contribute to the barrenness of the recirculating water.

The only perceptible evidence that enough mixing to enrich the surface layers is induced by the impingement of the west to northwesterly currents on the islands was shown in the analyses of zooplankton abundance by King and Hida (1954). They found that although the abundance of zooplankton was almost uniform throughout the region, the upstream area to the south and east of the island of Hawaii yielded, on the average, the lowest volumes (cruises 10 and 12, stations 26 to 30). A comparison of the plots of the abundance of zooplankton (King and Hida 1954, fig. 10) with the lateral plots of geostrophic currents for cruises 10 and 12 (figs. 13 and 24) indicates that there were slight maxima at, or near, the cyclonic eddies in the lee of the islands during both cruises and at station 31 during cruise 10. However, two other maxima occurred that could not be attributed to, nor remotely connected with, any unusual hydrographic features, the first at station 5 during cruise 10 and the second at station 6 during cruise 12. The first was particularly interesting since it was 21 ml/1,000m^3 higher than or 1.5 times that of any other station, and it occurred at the same station as the inexplicable high inorganic phosphate content in the upper 100 m. during cruise 12.

The writer believes that the occurrence of the zooplankton maxima at or near the centers of the cyclonic eddies and the frequent occurrence of high salinities and low temperatures at their centers are the result of divergent motion which causes some enrichment of the surface water. The slightness of the maxima and the number of exceptions to the increase of salinity and decrease of temperature at the centers indicate that vertical motion is small and intermittent at best.

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FIGURES

Frontispiece: The Windward or High Islands of the Hawaiian Archipelago.

Hugh M. Smith Cruise 1

1. Station positions.
2. Profiles of isobaric surfaces relative to the 1,000 decibar surface.
3. Geopotential topography of 0, 50, 100, 200, and 300 decibar surface.
4. Temperature profiles.
5. Variation in depth of the 75°, 70°, 65°, and 60°F. isotherms with time.
6. Sigma-t profiles.
7. Topography of the 23.6, 24.0, 25.0, and 26.0 sigma-t surfaces and salinity on these surfaces.
8. Salinity profiles.
9. Salinity at the sea surface.
10. Dissolved oxygen profiles.

Hugh M. Smith Cruise 10

11. Station positions.
12. Profiles of the isobaric surfaces relative to the 1,000 decibar surface.
13. Geopotential topography of the 0, 50, 100, 200, and 300 decibar surfaces.
14. Temperature profiles.
15. Topography of the 75°F. isotherm.
16. Sigma-t profiles.
17. Sigma-t at the sea surface.
18. Topography of the 23.2, 24.0, 25.0, and 26.0 sigma-t surfaces.
19. Salinity profiles.
20. Salinity at the sea surface.
21. Dissolved oxygen profiles.

Hugh M. Smith Cruise 12

22. Station positions.
23. Profiles of the isobaric surfaces relative to the 1,000 decibar surface.
24. Geopotential topography of the 0, 50, 100, and 200 decibar surfaces.
25. Current vectors computed from GEK measurements.

26. Temperature profiles.

27. Topography of the 75°F. isotherm.

28. Sigma-t profiles.

29. Topography of the 23.2, 24.0, 25.0, and 26.0 sigma-t surfaces.

30. Salinity profiles.

31. Salinity at the sea surface.

32. Inorganic phosphate profiles.

Miscellaneous

33. Profile of the Hawaiian Islands, Kauai to Hawaii.

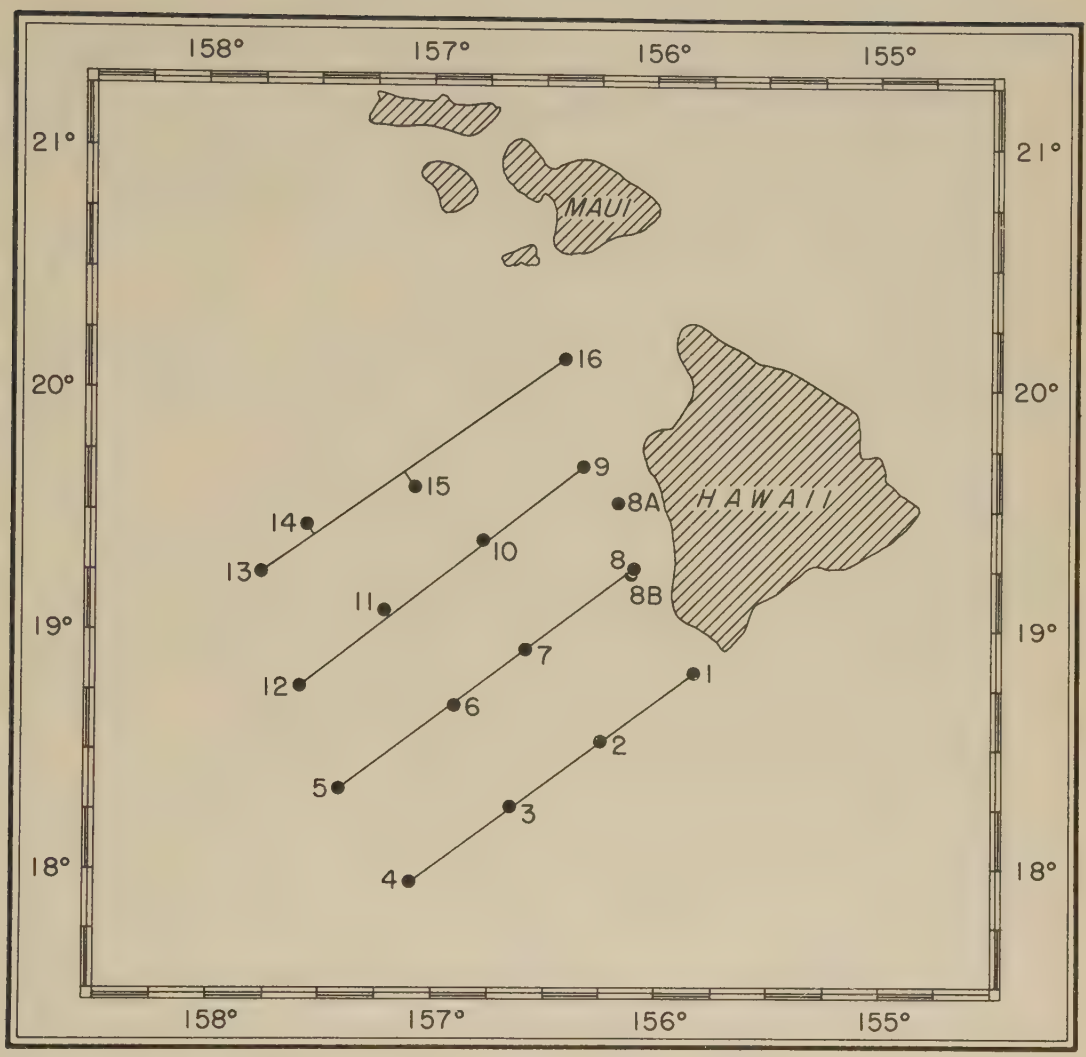

Fig. 1. -- H. M. Smith cruise 1, December 13-21, 1949, station positions. Solid lines indicate lines along which profiles of dynamic heights (dyn. M), temperature (°F), sigma-t, salinity (°/oo), and dissolved oxygen (ml/l) have been drawn.

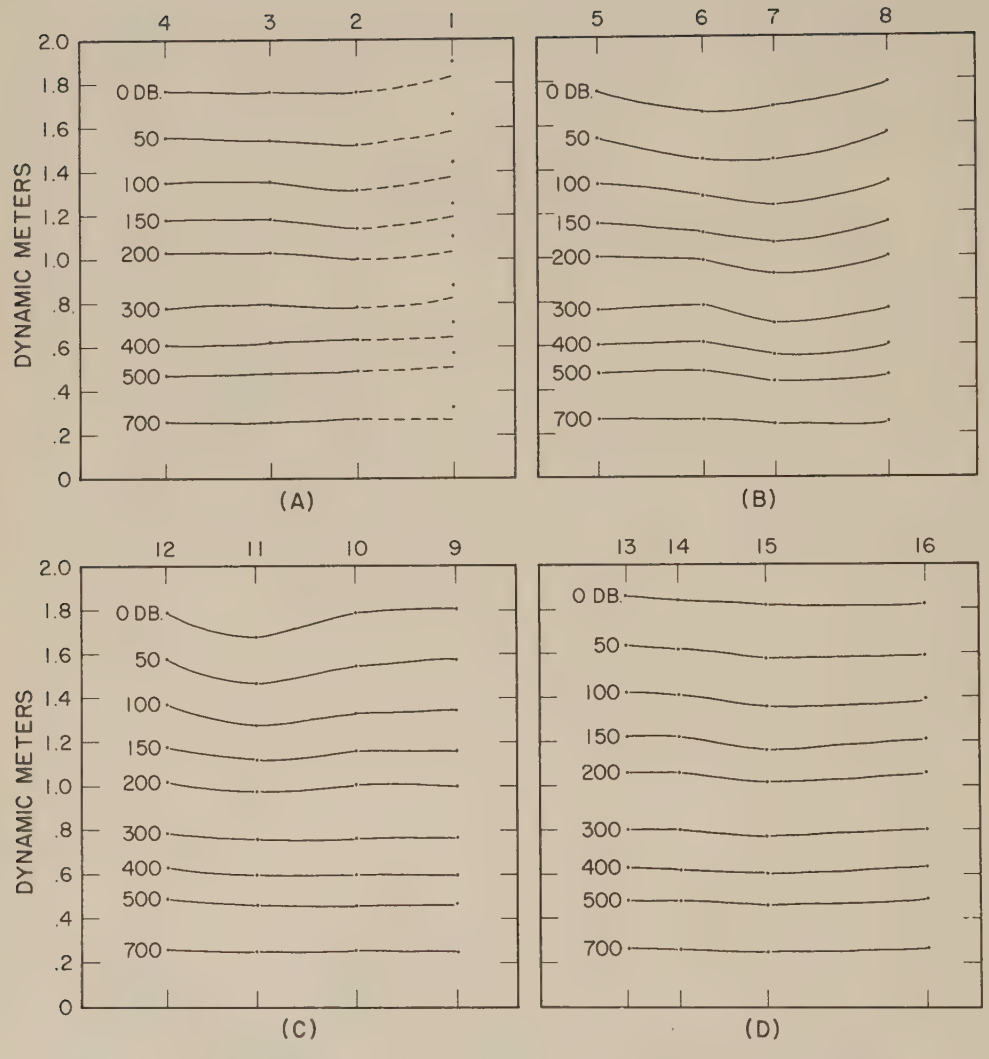

Fig. 2.--H. M. Smith cruise 2. Profiles of isobaric surfaces relative to the 1,000 db. surface. A. Stations 1-4, B. Stations 5-8, C. Stations 9-12, and D. Stations 11-16.

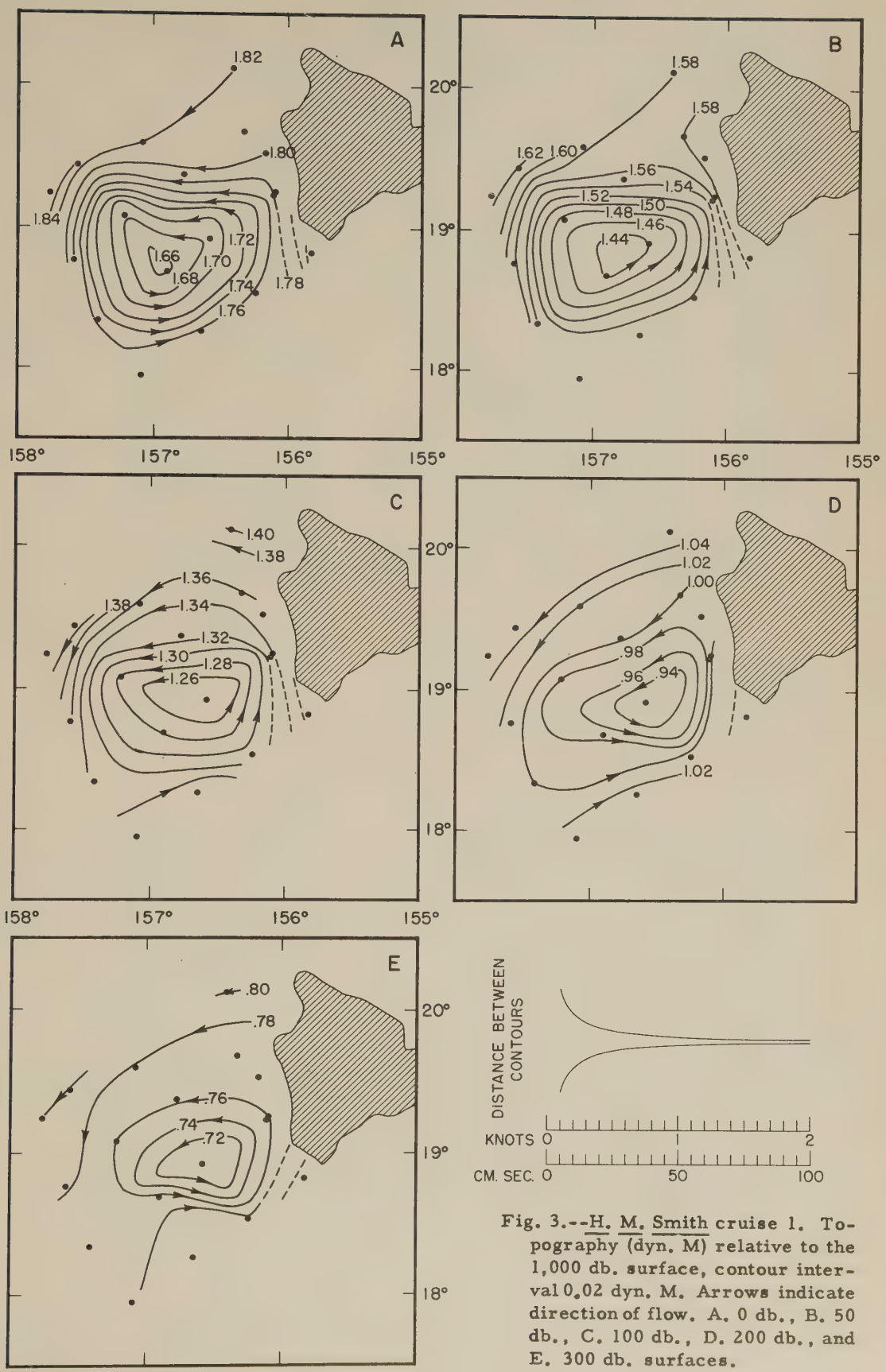

Fig. 3.--H. M. Smith cruise 1. Topography (dyn. M) relative to the 1,000 db. surface, contour interval 0.02 dyn. M. Arrows indicate direction of flow. A. 0 db., B. 50 db., C. 100 db., D. 200 db., and E. 300 db. surfaces.

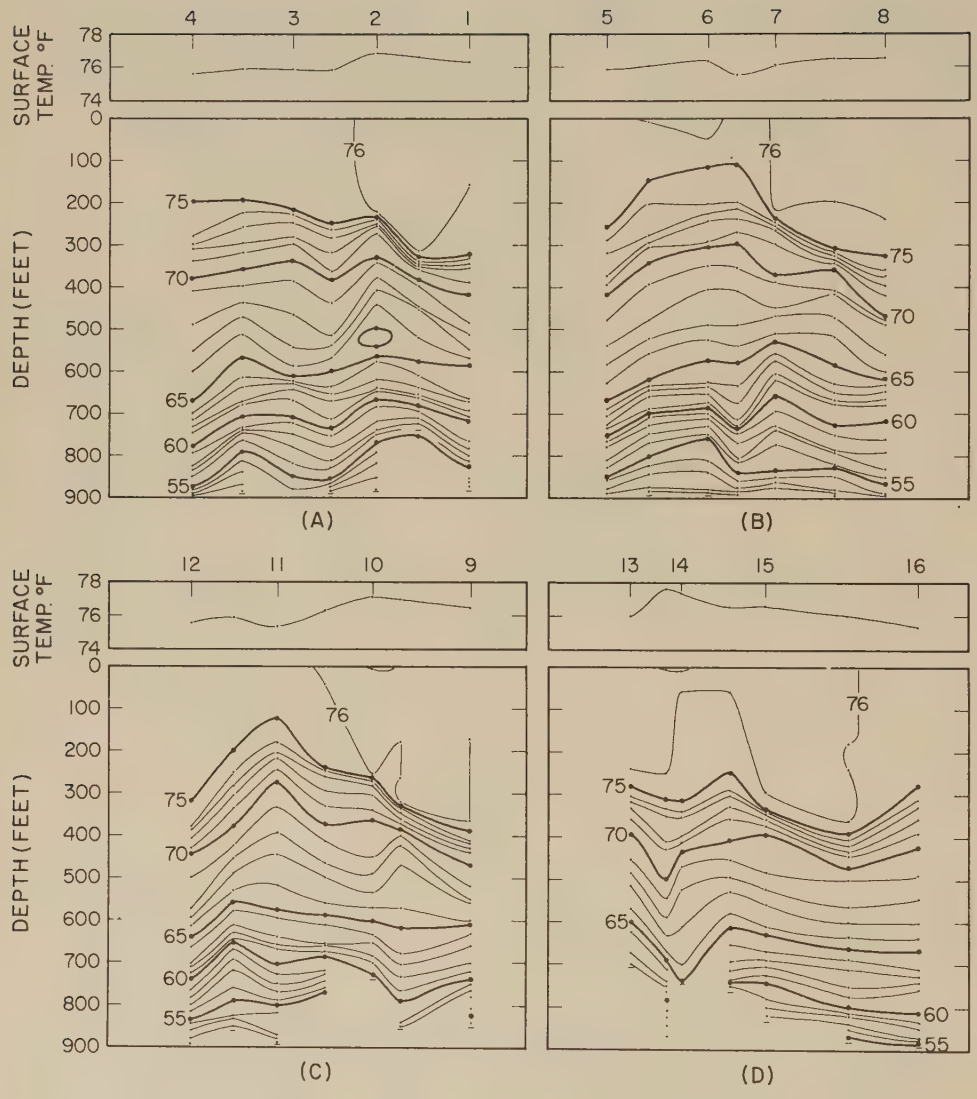

Fig. 4.--H. M. Smith cruise 1. Surface and vertical temperature profiles. Upper panels - surface temperatures (^{o}F) from "bucket" thermometer reading at each bathythermograph lowering. Lower panels - temperature profile based on bathythermograph lowerings, isotherm interval 1^{o}F, depth of lowering shown by small horizontal dashed line. A. Stations 1-3, B. Stations 5-8, C. Stations 9-12, and D. Stations 13-16.

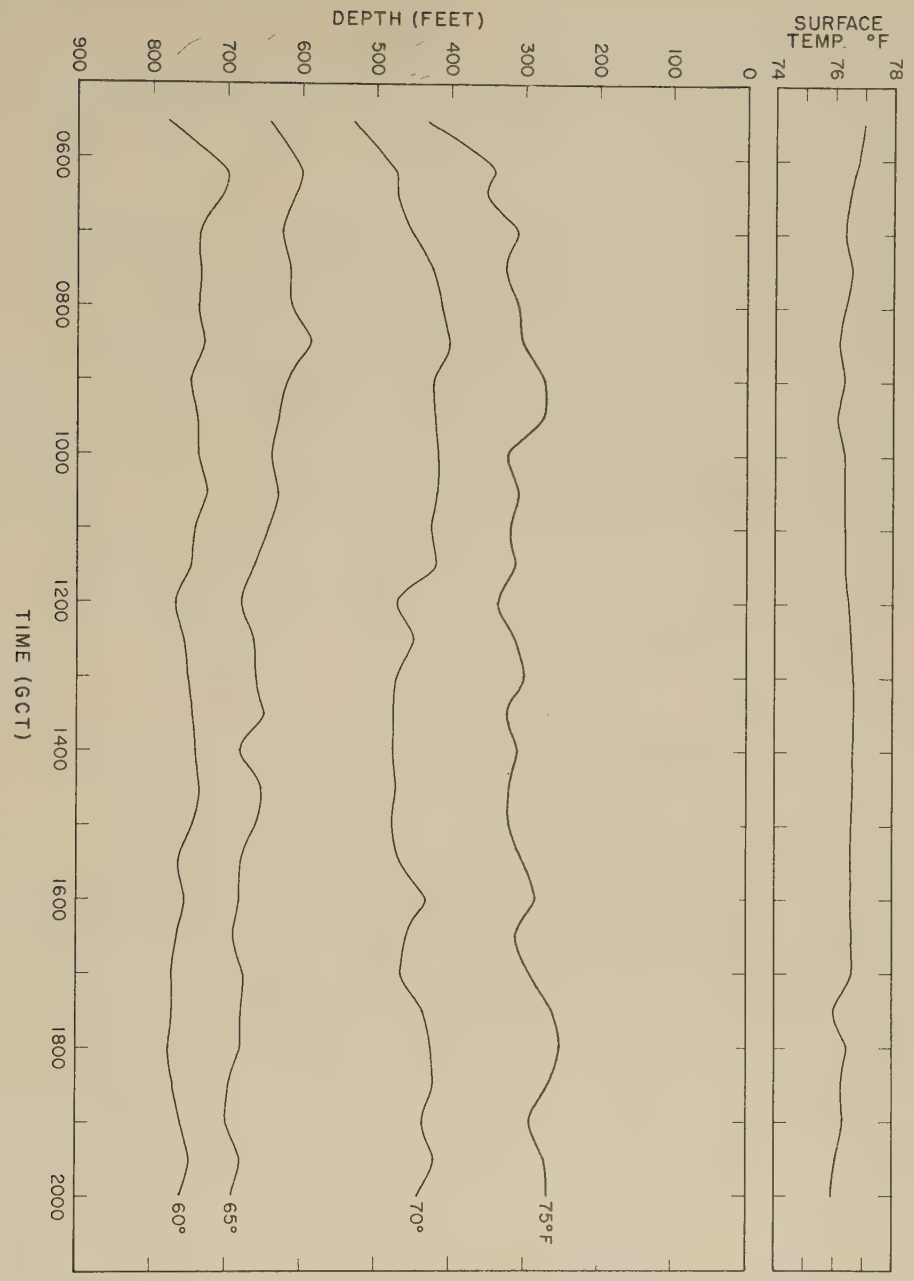

Fig. 5.--H. M. Smith cruise 1. Upper panel - variation of the surface temperature with time, Lower panel - variation in depth of isotherms with time from bathythermograph lowerings made December 13, 1949 while drifting from 19°41'N., 156°15'W. to 19°43'N., 156°20'W.

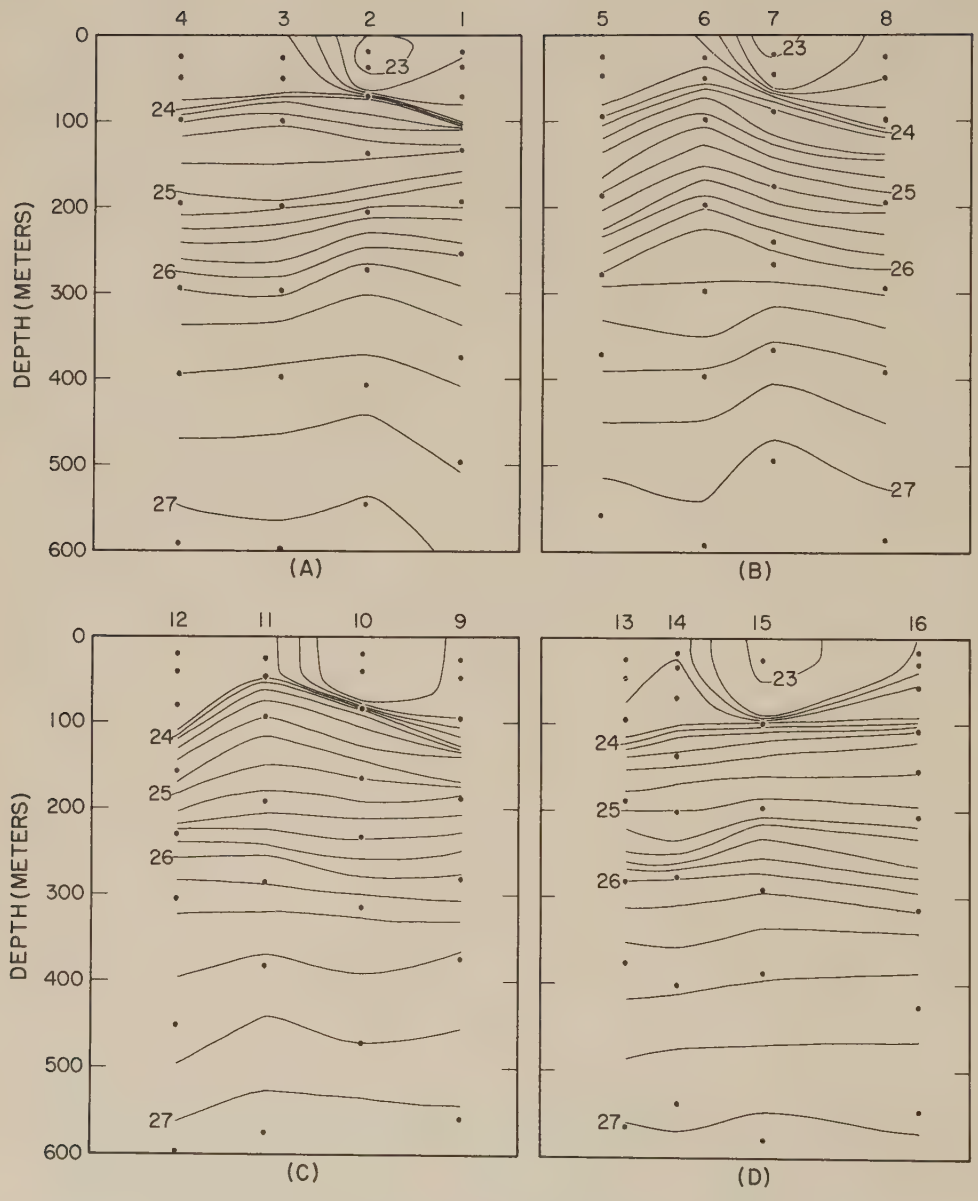

Fig. 6.--H. M. Smith cruise 1. Profiles of sigma-t, isopleth interval 0.2. A. Stations 1-4, B. Stations 5-8, C. Stations 9-12, and D. Stations 13-16.

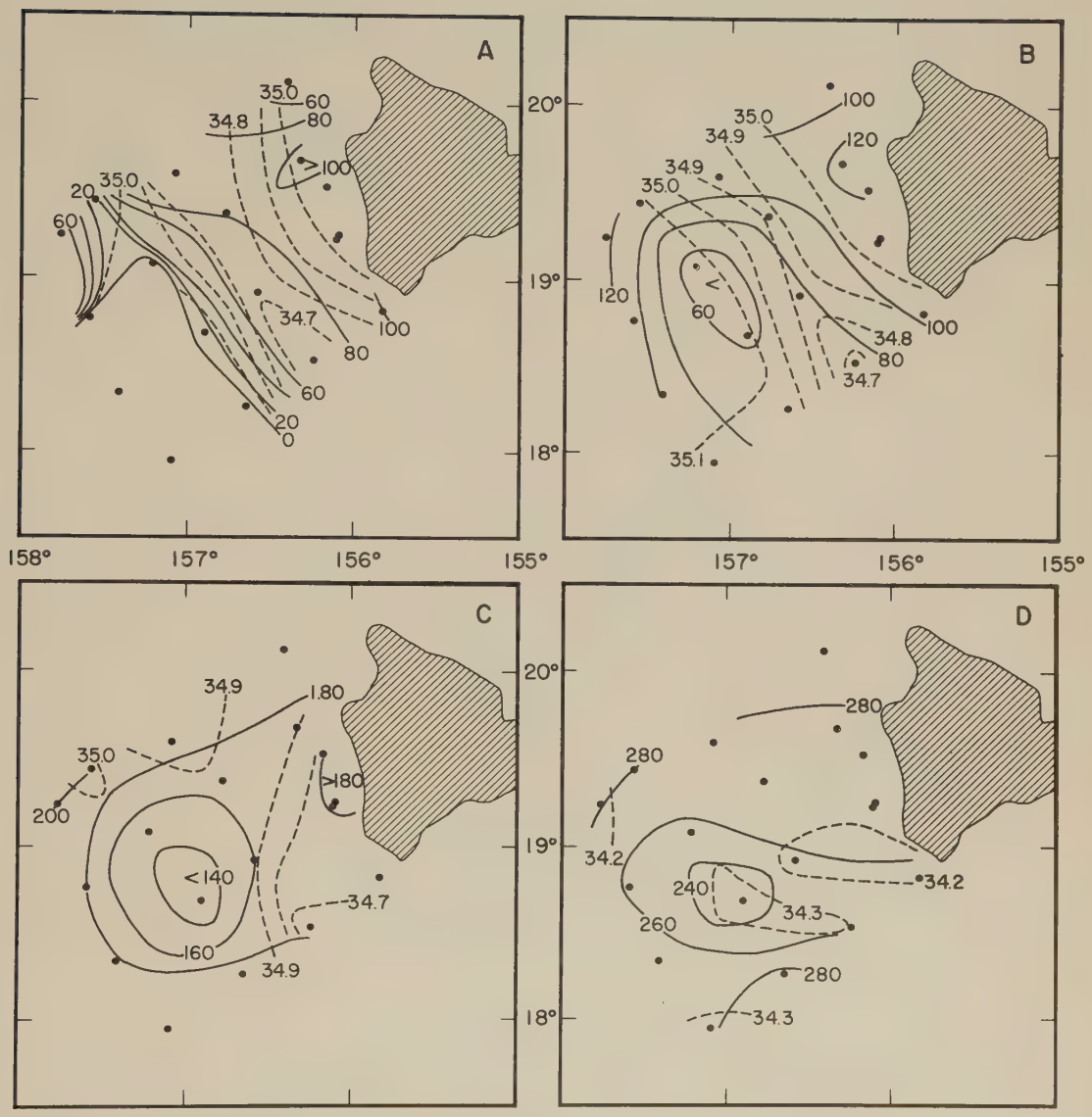

Fig. 7.--H. M. Smith cruise 1. Solid lines, topography of 23.6, 24.0, 25.0, and 26.0 sigma-t surfaces, contour interval 20 M. Dotted lines, salinity on the sigma-t surfaces, isohaline interval 0.1 °/oo. A. 23.6, B. 24.0, C. 25.0, and D. 26.0 sigma-t surfaces.

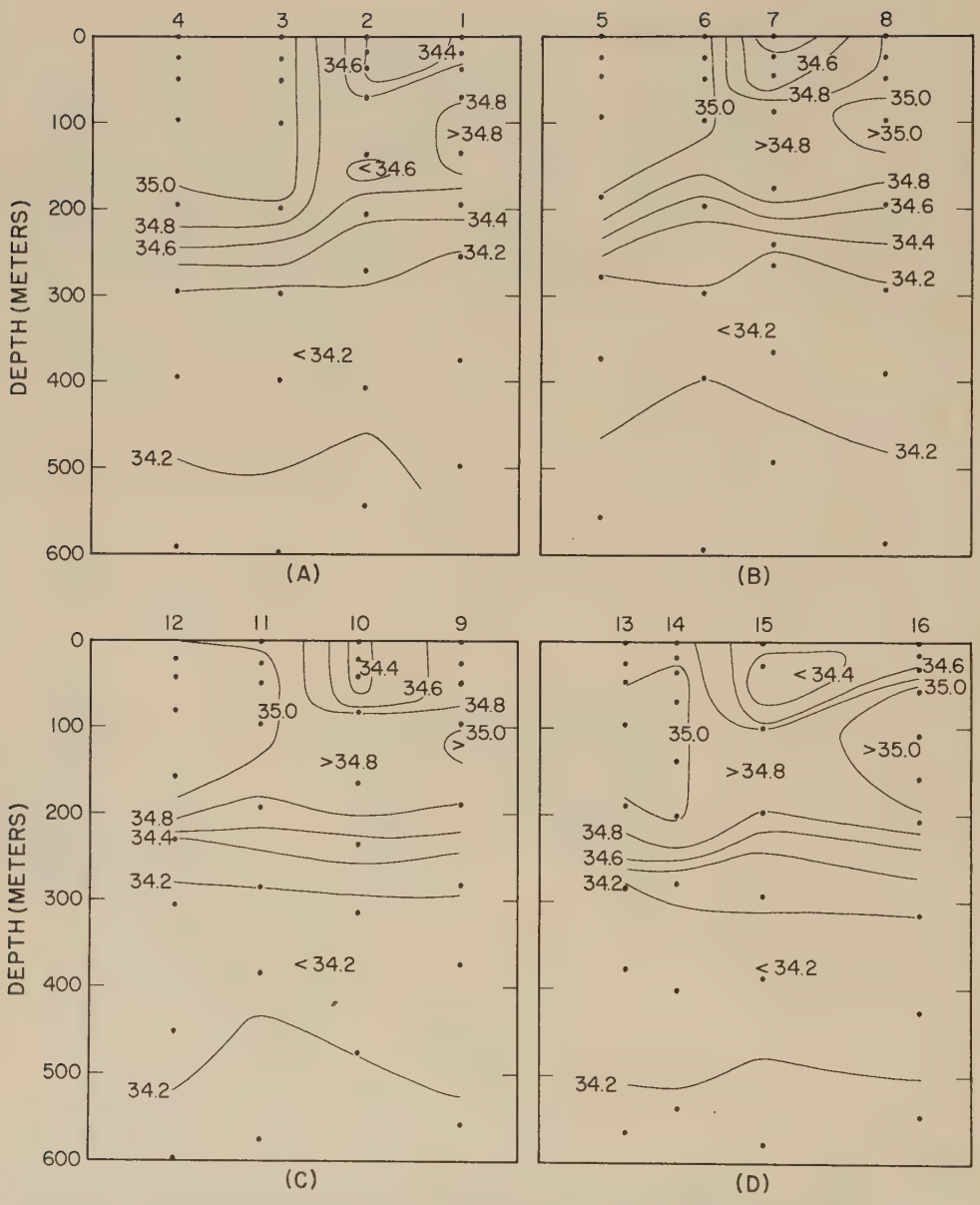

Fig. 8.-- H. M. Smith cruise 1. Profiles of salinity in °/oo, isohaline interval 0.2 °/oo. A. Stations 1-4, B. Stations 5-8, C. Stations 9-12, and D. Stations 13-16.

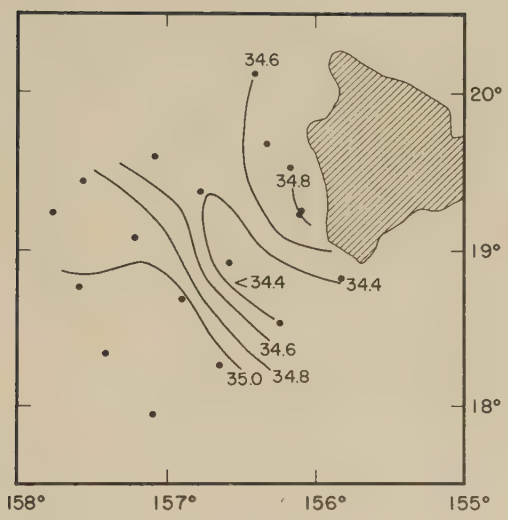

Fig. 9.--H. M. Smith cruise 1. Surface salinity in °/oo, isohaline interval 0.2 °/oo.

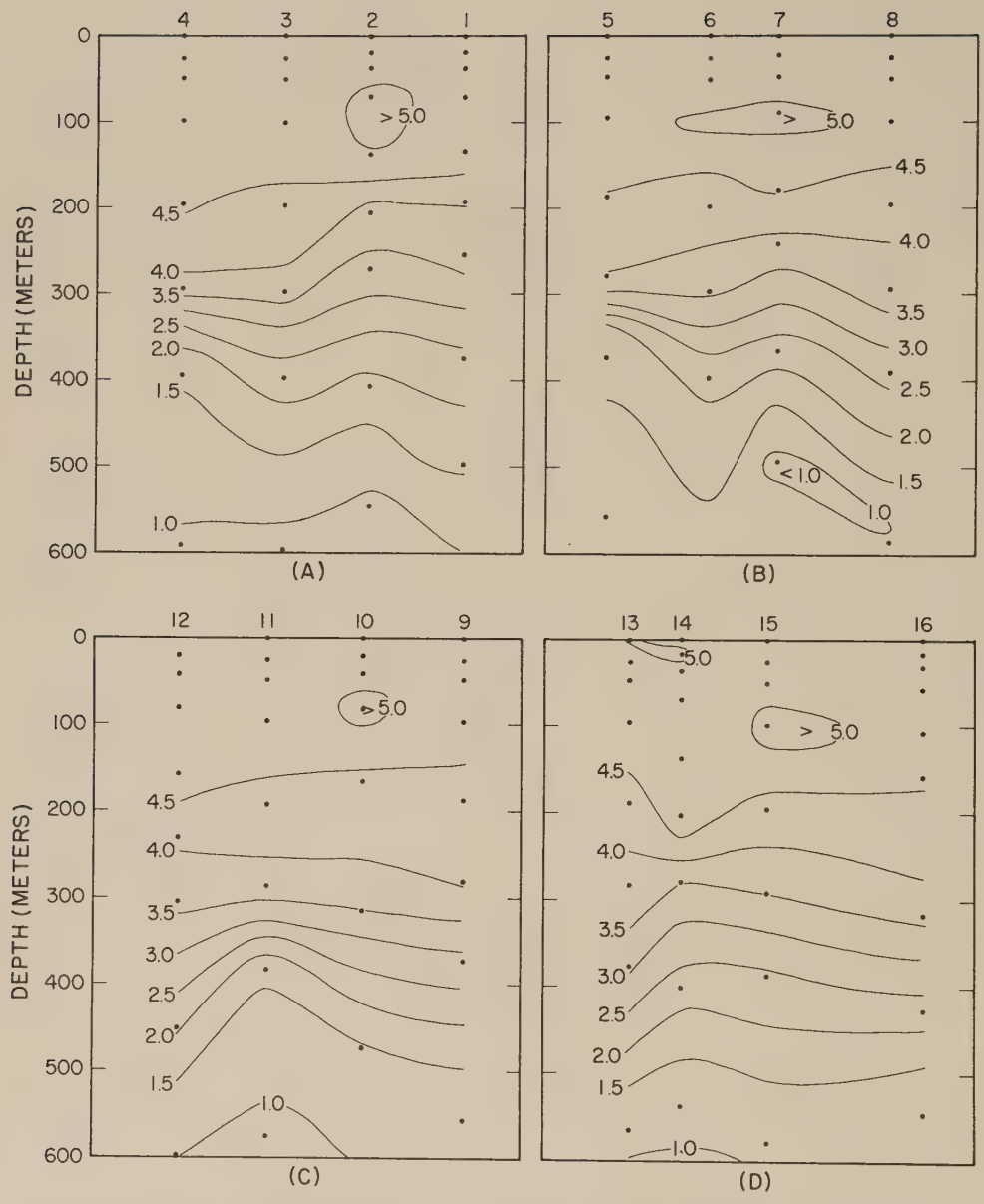

Fig. 10.--H. M. Smith cruise 1. Profiles of dissolved oxygen in ml/l, isopleth interval 0.5 ml/l. A. Stations 1-4, B. Stations 5-8, C. Stations 9-12, and D. Stations 11-16.

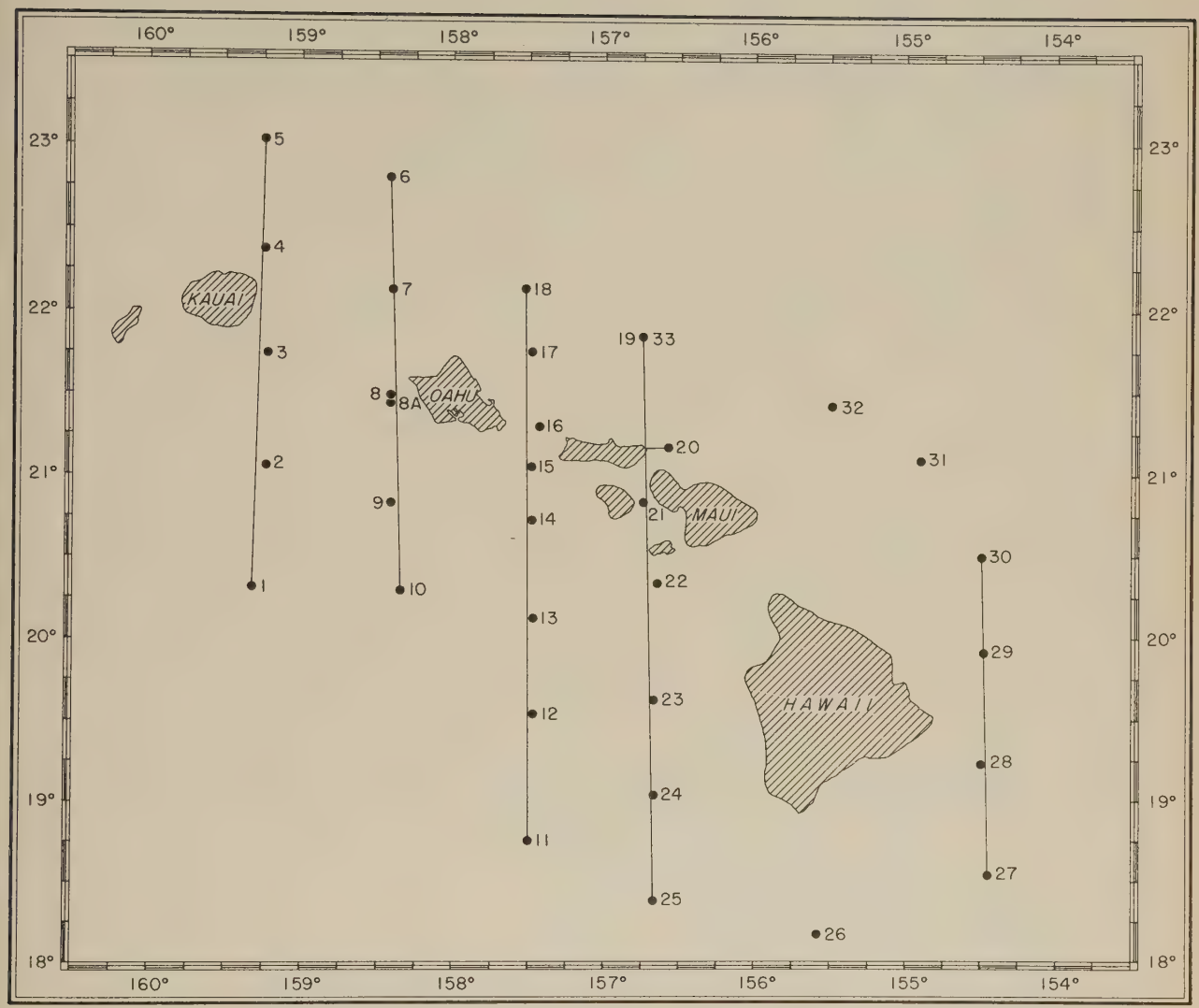

Fig. 11.--H. M. Smith cruise 10, July 19-31, 1951, station positions. Solid lines indicate lines along which profiles of dynamic heights (dyn. M), BT temperatures (°F), sigma-t, salinity (°/oo), and dissolved oxygen (ml/l) have been drawn.

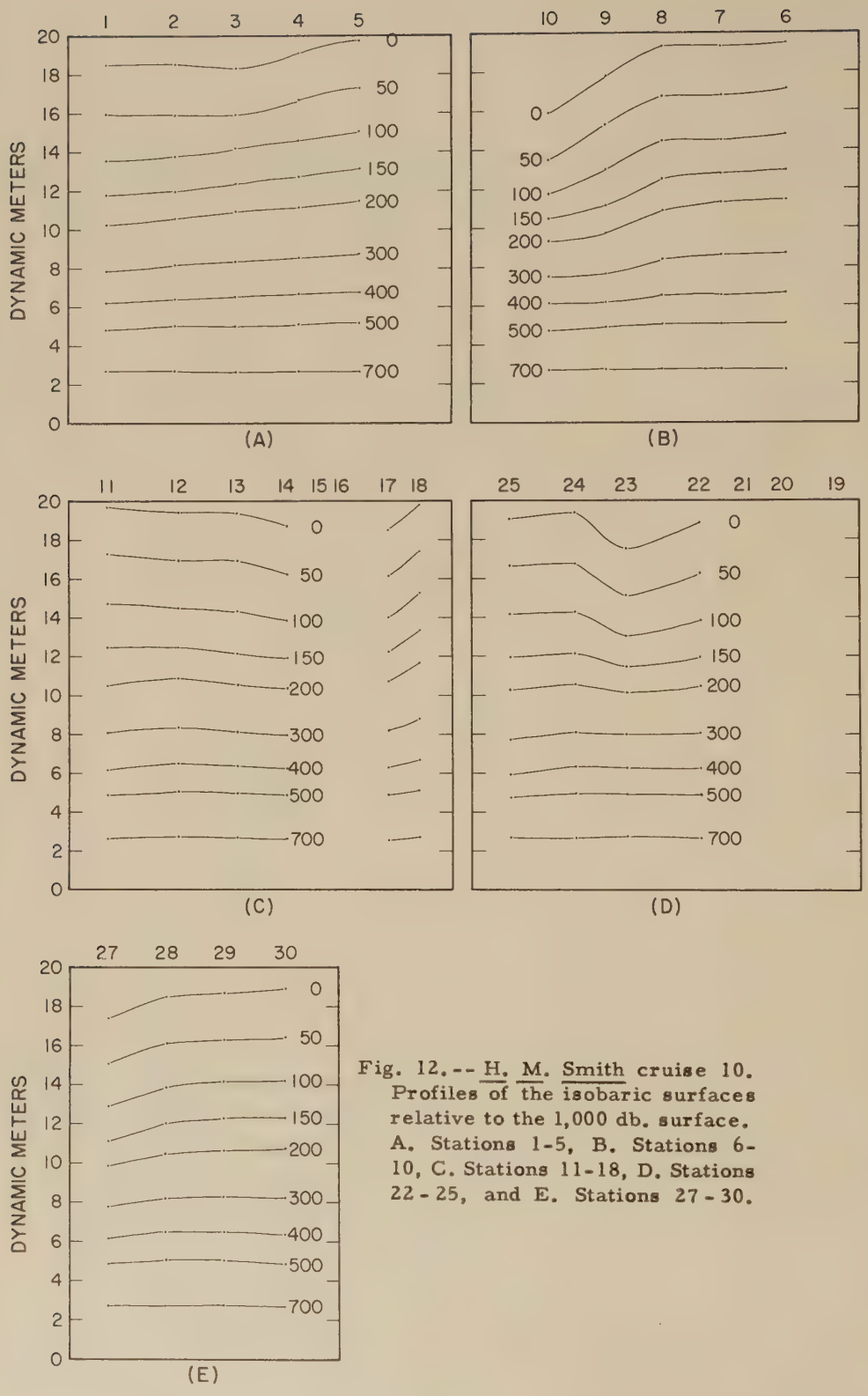

Fig. 12.--H. M. Smith cruise 10. Profiles of the isobaric surfaces relative to the 1,000 db. surface. A. Stations 1-5, B. Stations 6-10, C. Stations 11-18, D. Stations 22-25, and E. Stations 27-30.

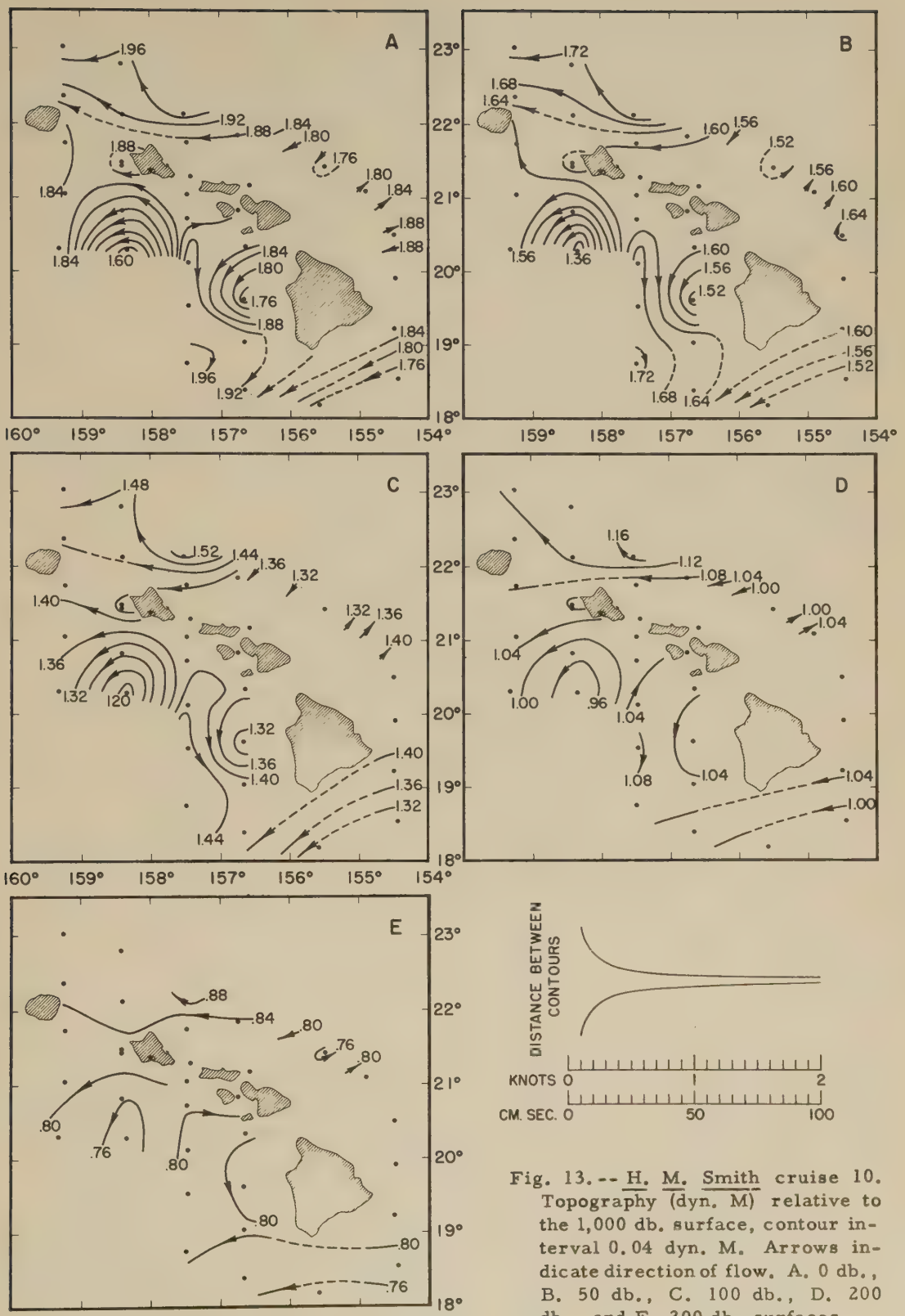

Fig. 13.--H. M. Smith cruise 10. Topography (dyn. M) relative to the 1,000 db. surface, contour interval 0.04 dyn. M. Arrows indicate direction of flow. A. 0 db., B. 50 db., C. 100 db., D. 200 db., and E. 300 db. surfaces.

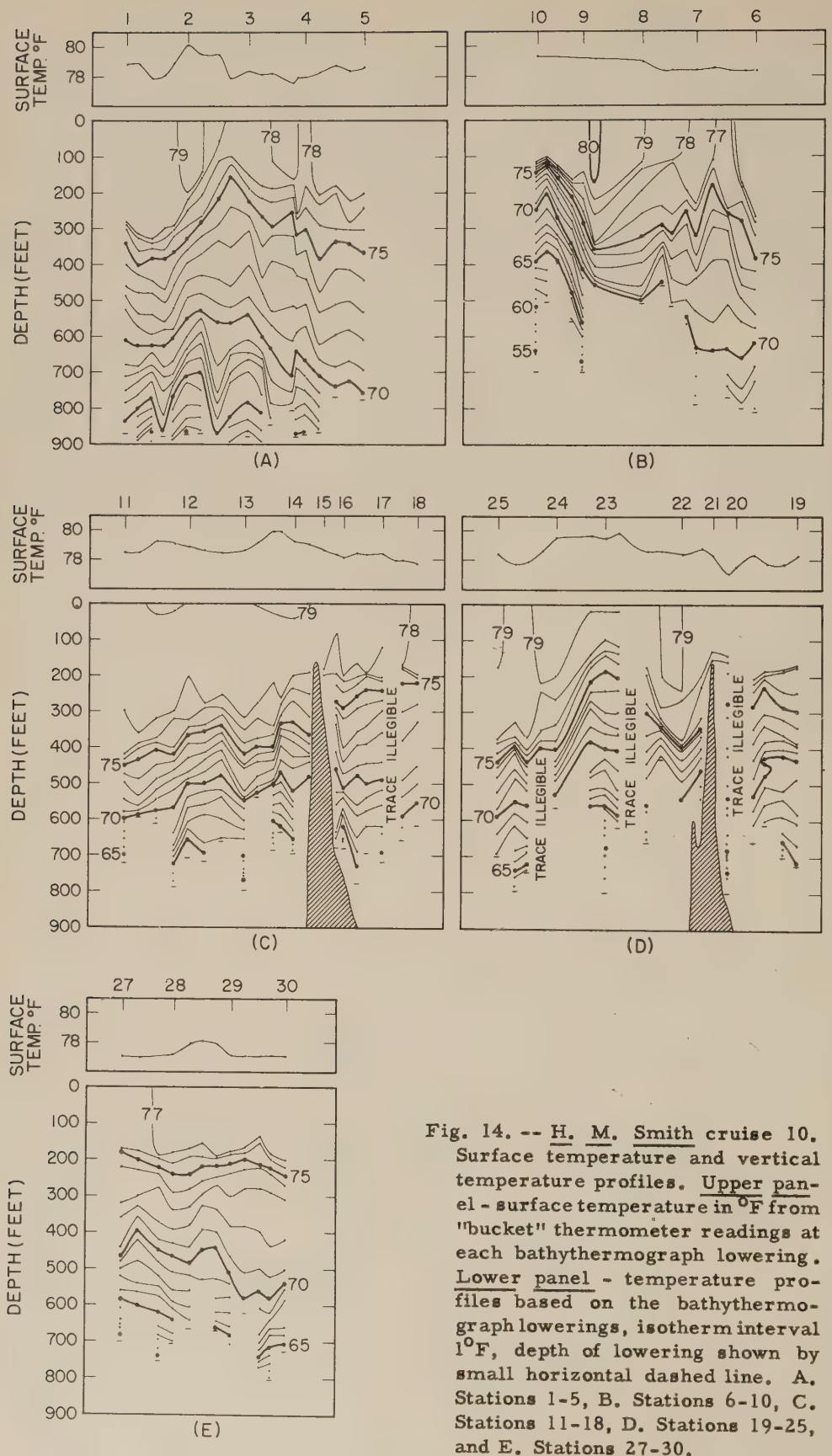

Fig. 14. -- H. M. Smith cruise 10. Surface temperature and vertical temperature profiles. Upper panel - surface temperature in °F from "bucket" thermometer readings at each bathythermograph lowering. Lower panel - temperature profiles based on the bathythermograph lowerings, isotherm interval 1°F, depth of lowering shown by small horizontal dashed line. A. Stations 1-5, B. Stations 6-10, C. Stations 11-18, D. Stations 19-25, and E. Stations 27-30.

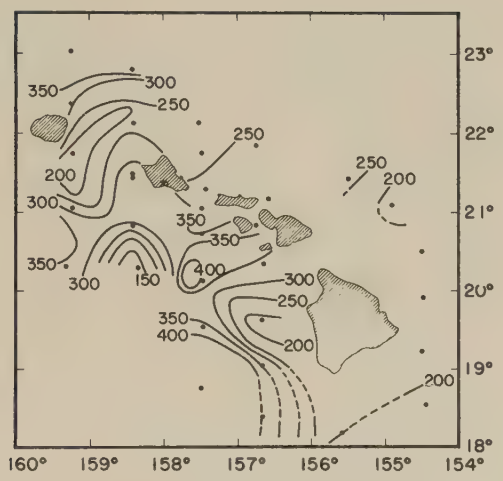

Fig. 15.-- H. M. Smith cruise 10. Topography in feet of the 75°F isotherm, contour interval 50 feet.

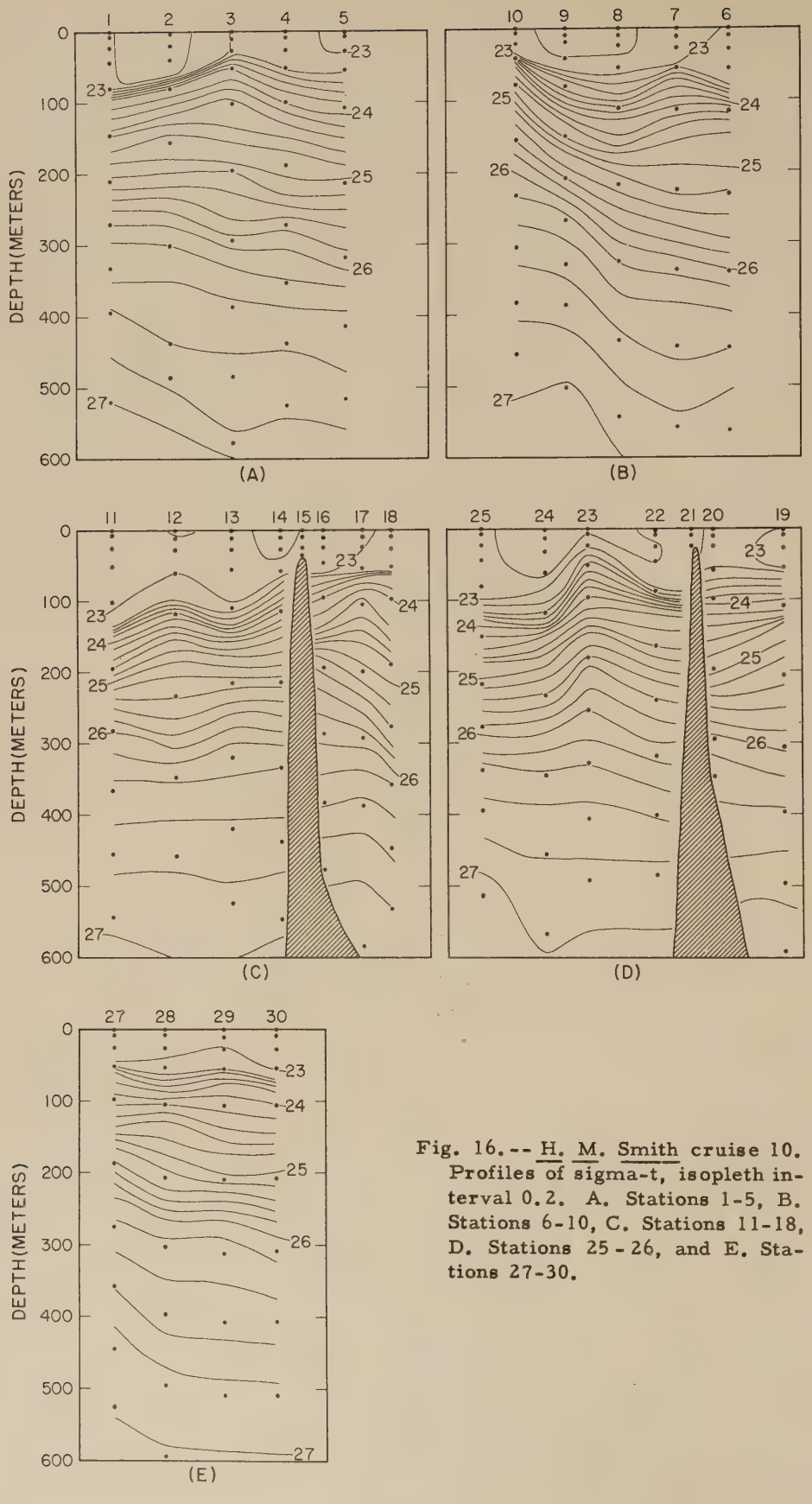

Fig. 16.-- H. M. Smith cruise 10. Profiles of sigma-t, isopleth interval 0.2. A. Stations 1-5, B. Stations 6-10, C. Stations 11-18, D. Stations 25 - 26, and E. Stations 27-30.

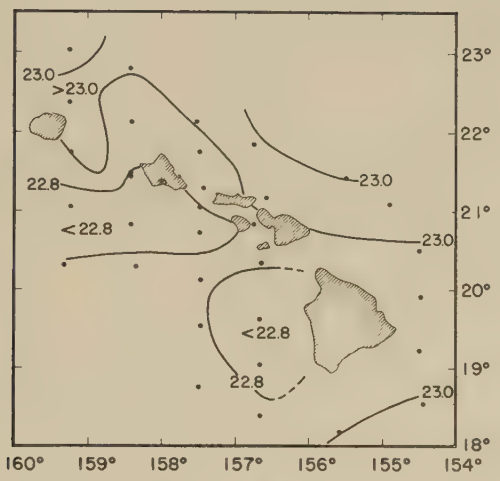

Fig. 17.-- H. M. Smith cruise 10. Surface sigma-t, isopleth interval 0.2.

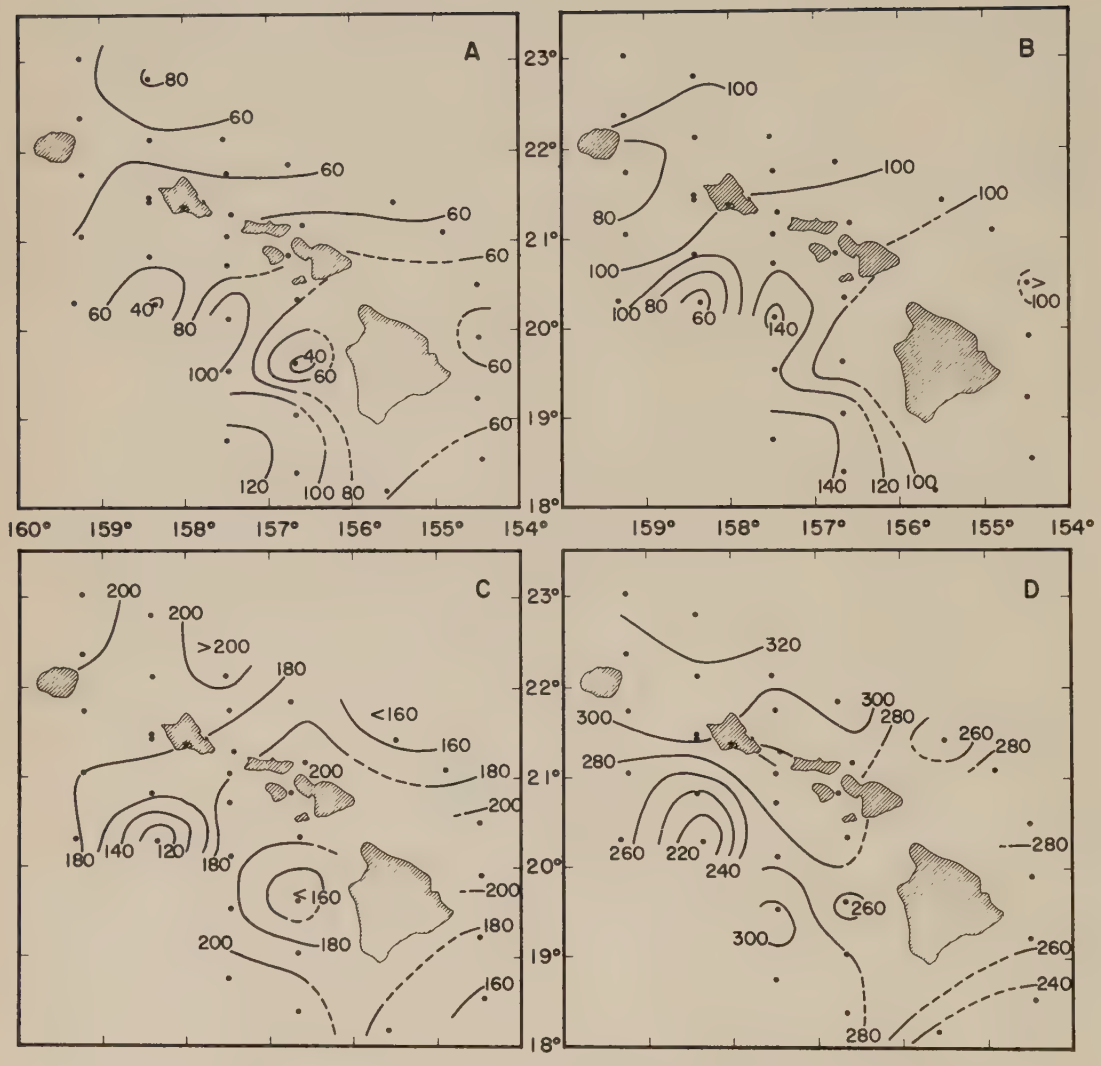

Fig. 18.--H. M. Smith cruise 10. Topography in meters of 23.2, 24.0, 25.0, and 26.0 sigma-t surfaces. Contour interval 20.0 meters. A. 23.2, B. 24.0, C. 25.0, and D. 26.0 sigma-t surfaces.

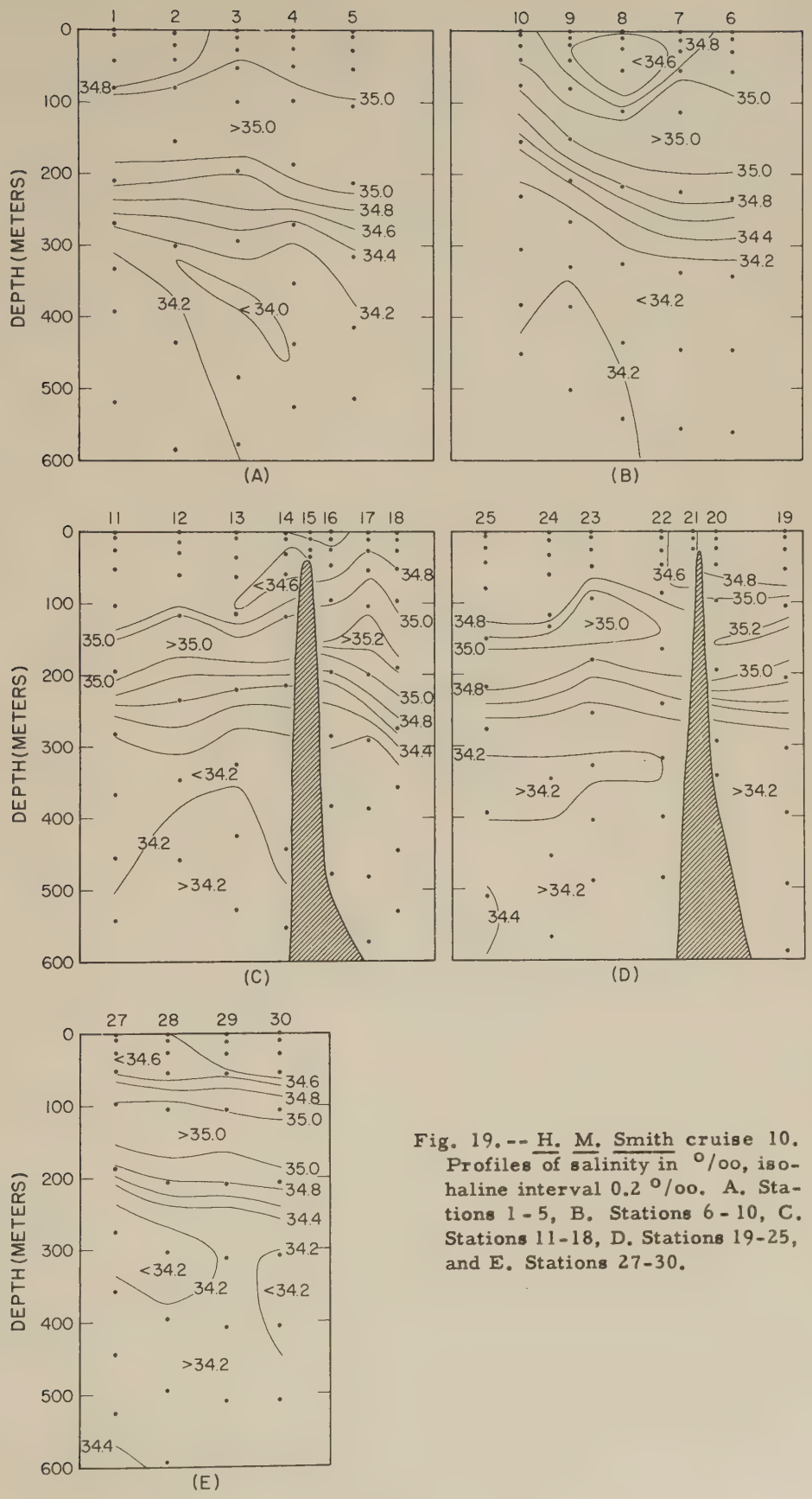

Fig. 19.-- H. M. Smith cruise 10. Profiles of salinity in °/oo, isohaline interval 0.2 °/oo. A. Stations 1 - 5, B. Stations 6 - 10, C. Stations 11-18, D. Stations 19-25, and E. Stations 27-30.

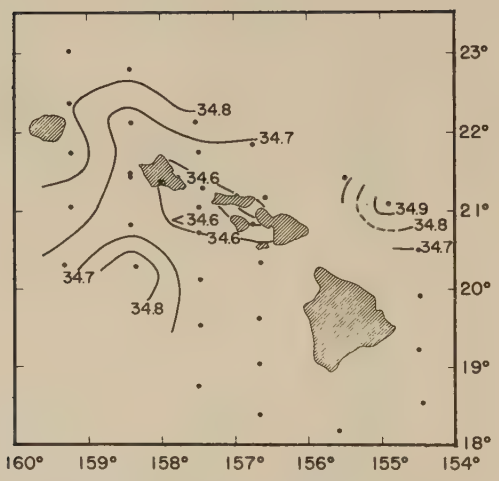

Fig. 20.-- H. M. Smith cruise 10. Surface salinity in °/oo, isohaline interval 0.1 °/oo.

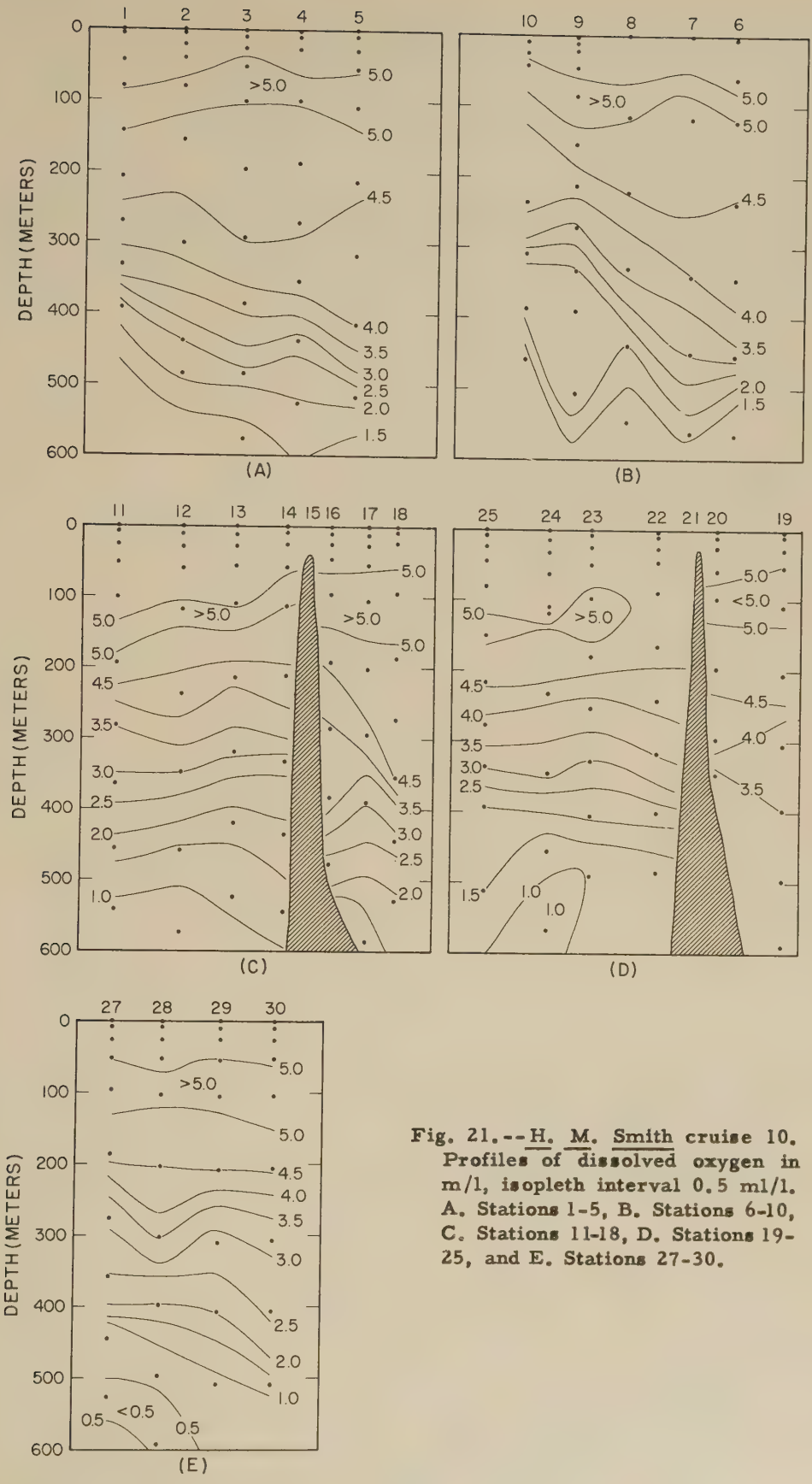

Fig. 21.--H. M. Smith cruise 10. Profiles of dissolved oxygen in m/l, isopleth interval 0.5 ml/l. A. Stations 1-5, B. Stations 6-10, C. Stations 11-18, D. Stations 19-25, and E. Stations 27-30.

Fig. 22.-- H. M. Smith cruise 12, October 23 to November 2, 1951, station positions. Solid lines indicate lines along which profiles of dynamic heights (dyn. M), BT temperatures (°F), sigma-t, salinity (°/oo), and inorganic phosphate (μg at/l) have been drawn.

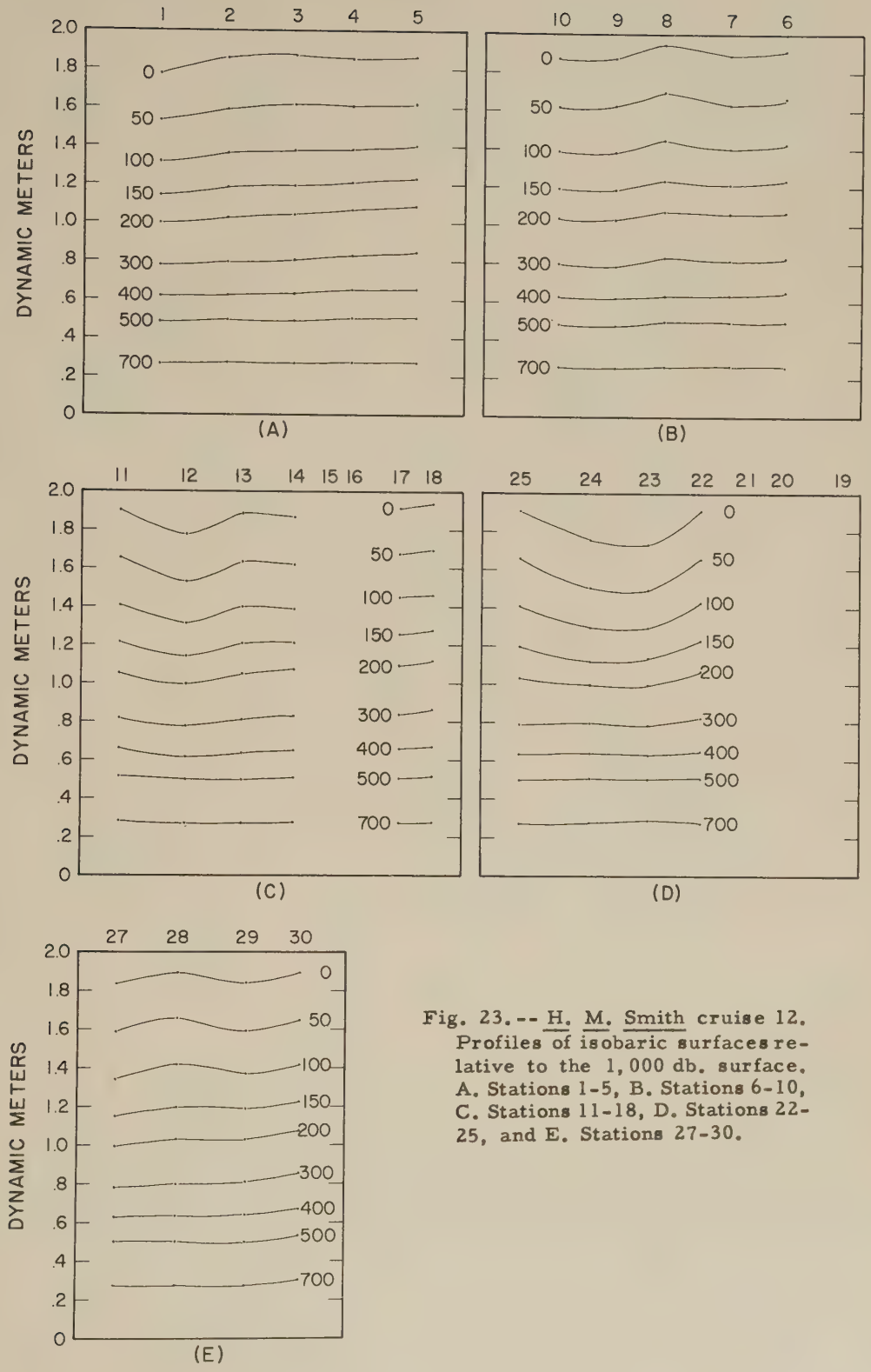

Fig. 23.-- H. M. Smith cruise 12. Profiles of isobaric surfaces relative to the 1,000 db. surface. A. Stations 1-5, B. Stations 6-10, C. Stations 11-18, D. Stations 22-25, and E. Stations 27-30.

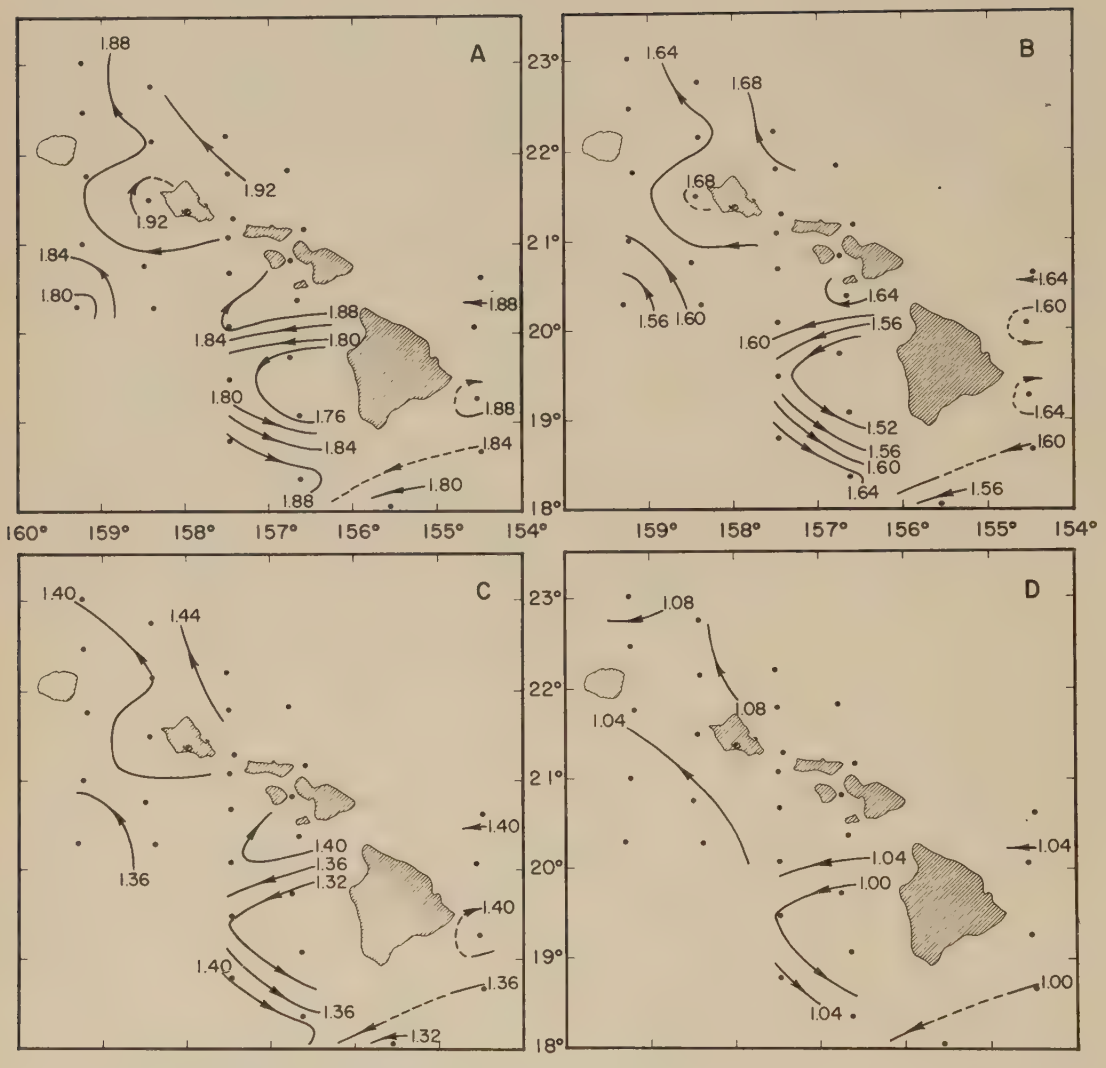

Fig. 24. --H. M. Smith cruise 12. Topography (dyn. M) relative to the 1,000 db. surface, contour interval 0.04 dyn. M. Arrows indicate direction of flow. A. 0 db., B. 50 db., C. 100 db., and D. 200 db. surfaces.

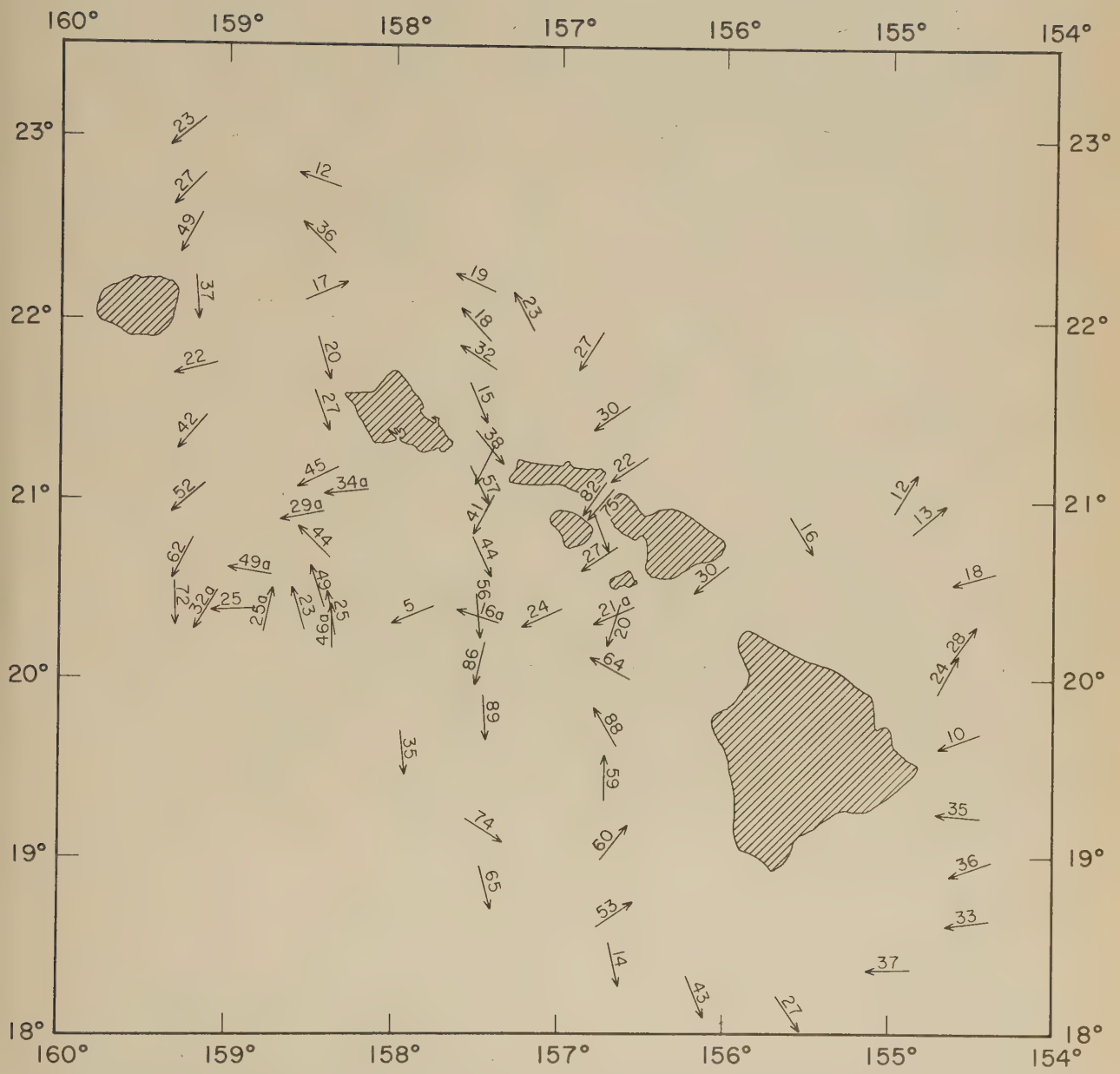

Fig. 25.--H. M. Smith cruise 12. Current vectors computed from GEK measurements, velocities in cm/sec. "a" indicates observations made during the recheck of the area south of Oahu at the end of the cruise.

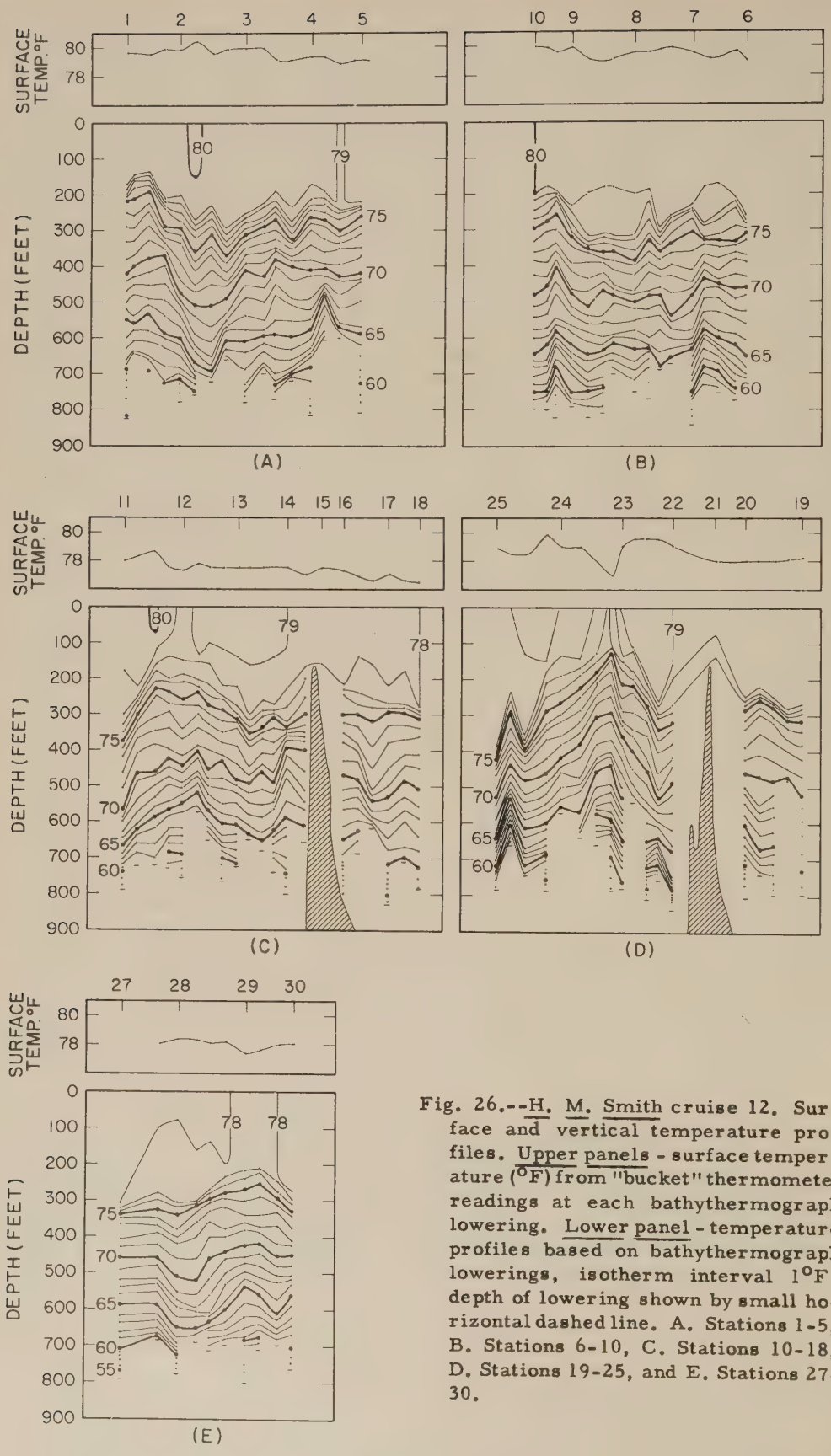

Fig. 26.--H. M. Smith cruise 12. Surface and vertical temperature profiles. Upper panels - surface temperature (°F) from "bucket" thermometer readings at each bathythermograph lowering. Lower panel - temperature profiles based on bathythermograph lowerings, isotherm interval 1°F, depth of lowering shown by small horizontal dashed line. A. Stations 1-5, B. Stations 6-10, C. Stations 10-18, D. Stations 19-25, and E. Stations 27-30.

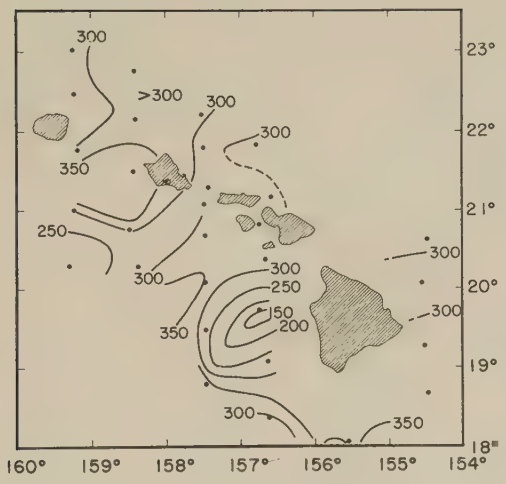

Fig. 27. --H. M. Smith cruise 12. Topography in feet of the 75.0°F isotherm, contour interval 50 feet.

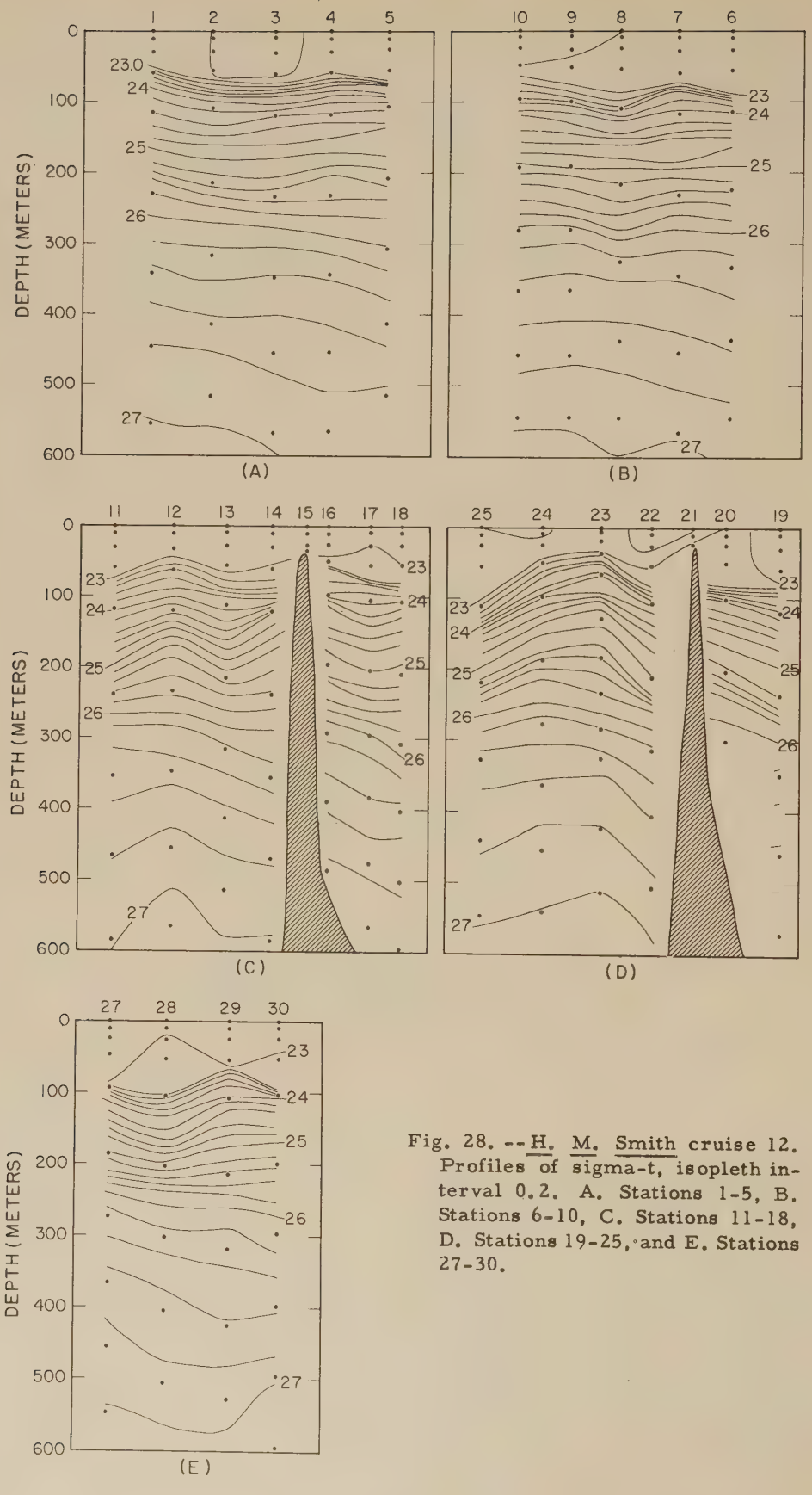

Fig. 28. --H. M. Smith cruise 12. Profiles of sigma-t, isopleth interval 0.2. A. Stations 1-5, B. Stations 6-10, C. Stations 11-18, D. Stations 19-25, and E. Stations 27-30.

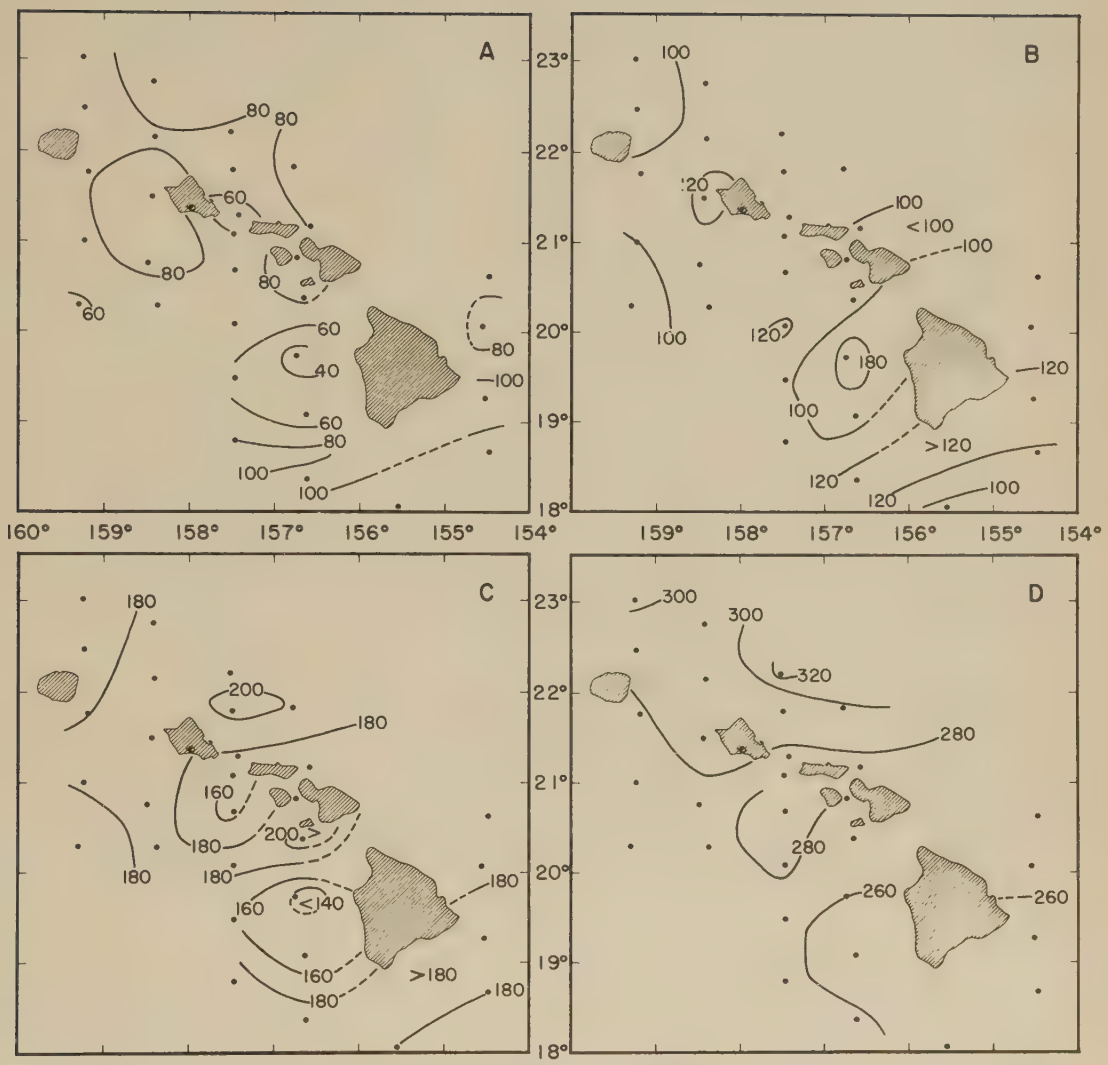

Fig. 29.-- H. M. Smith cruise 12. Topography in meters of the 23.2, 24.0, 25.0, and 26.0 sigma-t surfaces. Contour interval 20 meters. A. 23.2, B. 24.0, C. 25.0, and D. 26.0 surfaces.

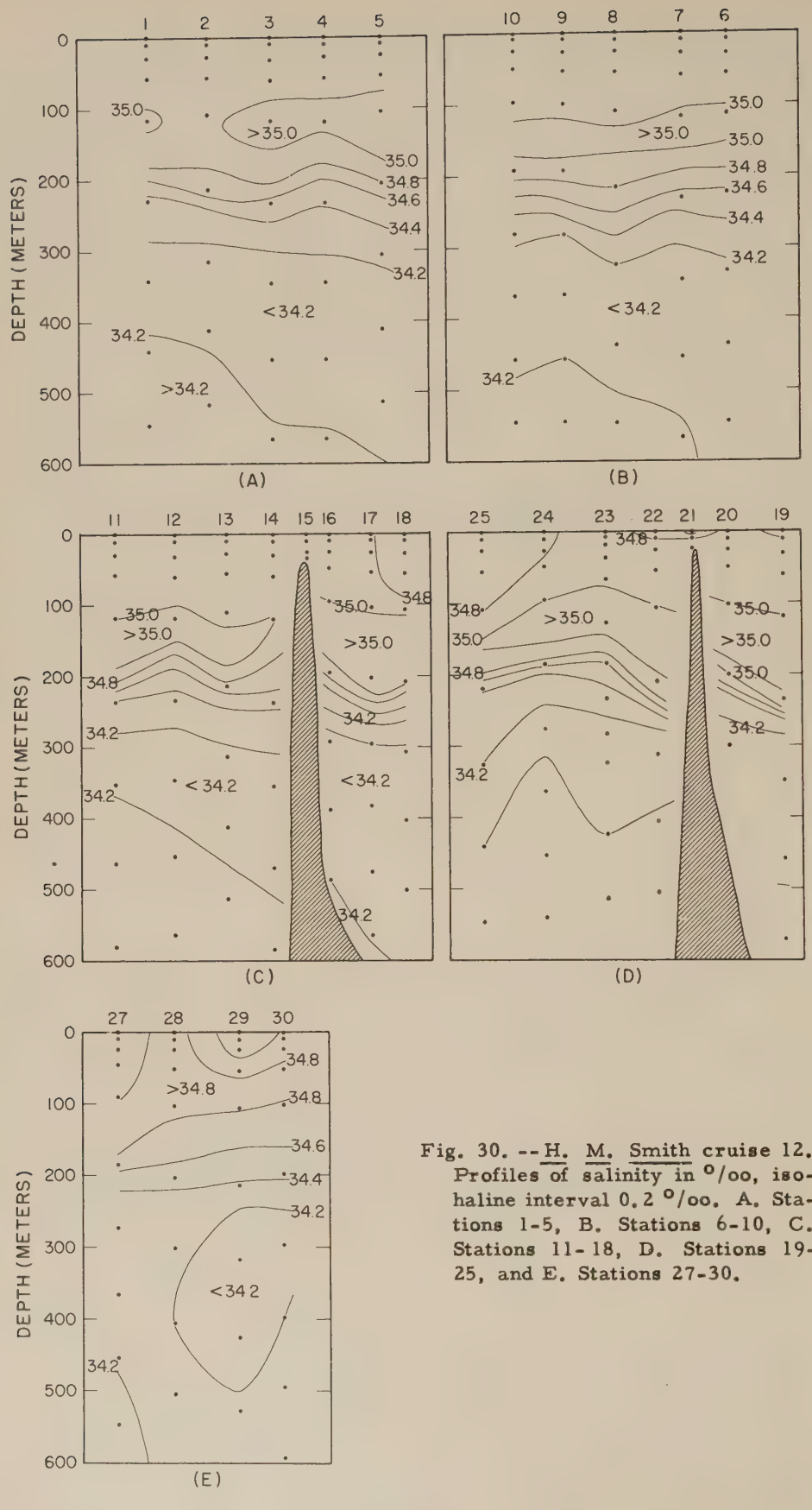

Fig. 30. --H. M. Smith cruise 12. Profiles of salinity in °/oo, isohaline interval 0.2 °/oo. A. Stations 1-5, B. Stations 6-10, C. Stations 11-18, D. Stations 19-25, and E. Stations 27-30.

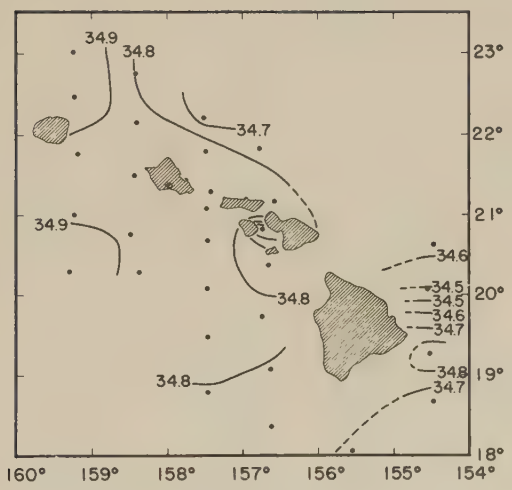

Fig. 31.--H. M. Smith cruise 12. Surface salinity in °/oo, isohaline interval 0.10 °/oo.

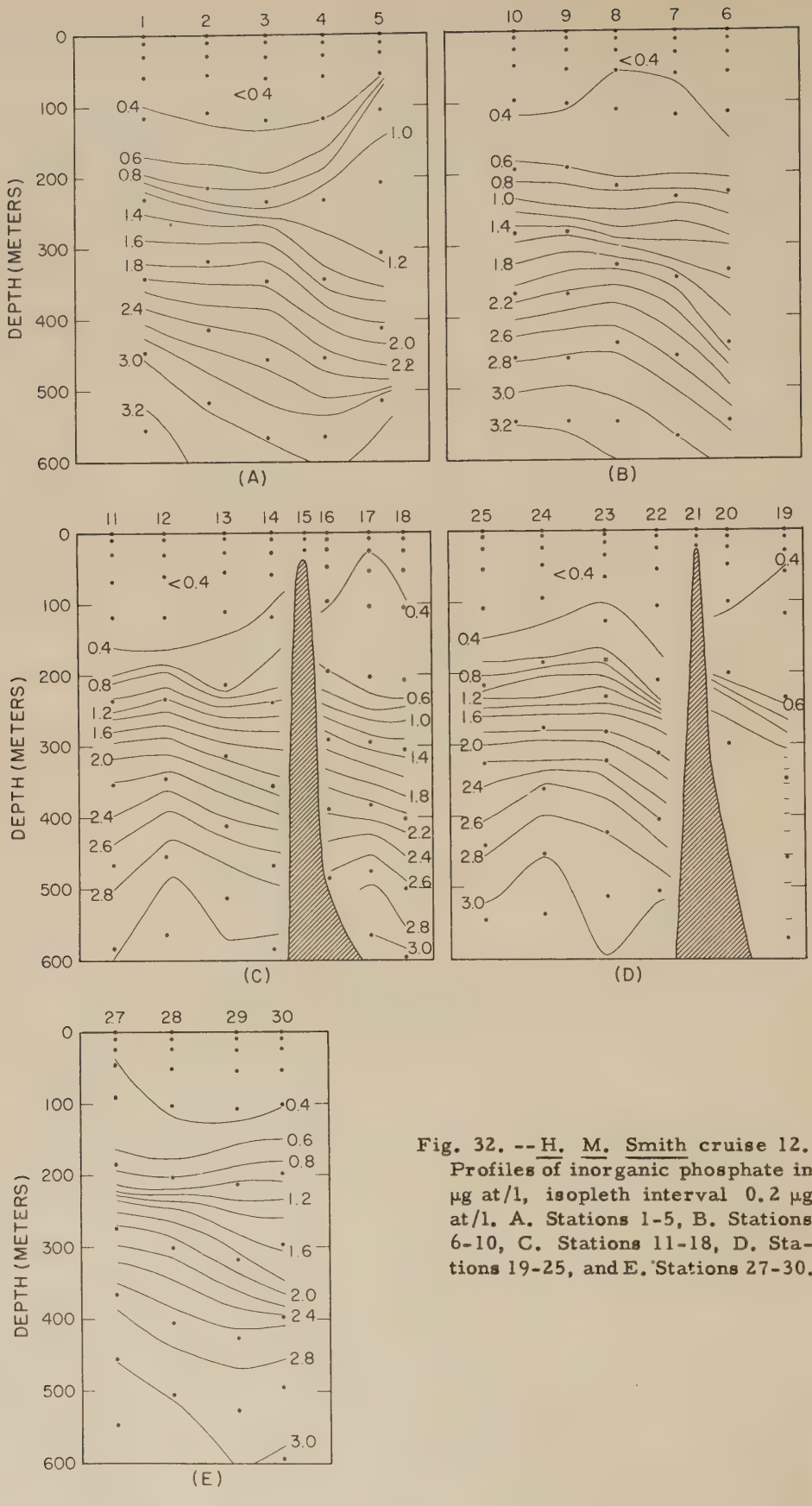

Fig. 32. --H. M. Smith cruise 12. Profiles of inorganic phosphate in µg at/l, isopleth interval 0.2 µg at/l. A. Stations 1-5, B. Stations 6-10, C. Stations 11-18, D. Stations 19-25, and E. Stations 27-30.

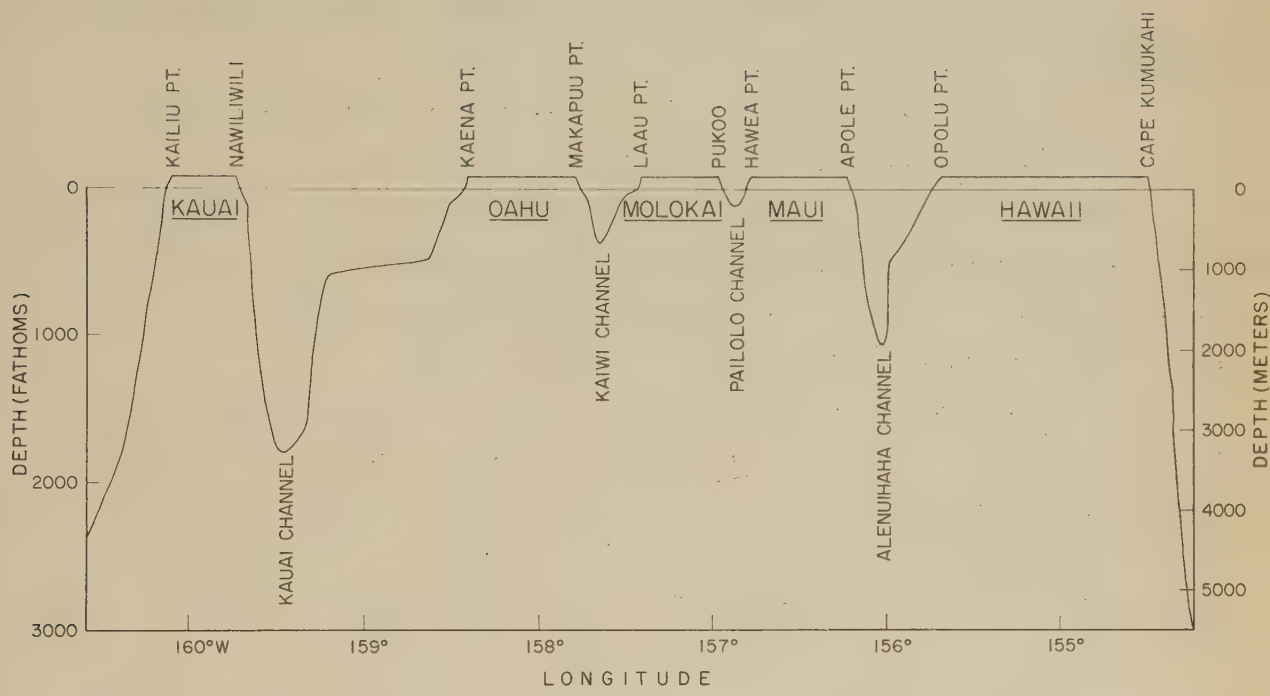

Fig. 33.--Cross section of the Windward or High Islands of the Hawaiian Archipelago.

Remarks about the oceanographic data

Weather was recorded according to the ww code as it appears in The U.S. ather Bureau Circular M, Instructions to Marine Meteorological Observers.

Wind velocity was measured using an anemometer located 30 m. above the a surface.

In the tabulated data, the horizontal line(s) between depths separates e two or more casts necessary during the particular station.

Whenever there is no doubt concerning data being in error (Nansen bottle etrip, bottle leakage, etc.), these data are not carried in the tabulations and a otnote is appended. If values are doubtful, but there is no positive evidence of error, the data are carried with appropriate footnotes.

When the interpolated and calculated values are shown for greater depths an the observed values, they were obtained by extrapolation using the data from joining stations as a guide.

STATION 1

M/V Hugh M. Smith: Cruise 1, 18°50'N., 155°49'W., December 17, 1949. Messenger time: 2313 GCT. Weather: scattered clouds, cirrus. Wind: 100°, 4 kt. Sea: 3-5 ft. Wire angle: 42°. Depth of water: 1400 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00		34.42		4.84	
18	24.42	34.42	23.10	4.80	
36	24.52	34.70	23.28	4.82	
70	24.41	34.79	23.38	4.84	
133	19.70	34.89	24.77	4.84	
193	16.20	34.55	25.37	4.01	
253	12.09	34.18	25.96	3.88	
374	08.73	34.14	26.51	2.40	
497	06.75	34.11	26.77	1.57	
623	05.94	34.20	26.95	0.86	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	24.51	34.42	23.05	0.000	1.899
10	24.48	34.42	23.08	0.048	1.851
20	24.45	34.42	23.09	0.096	1.803
30	24.50	34.58	23.20	0.144	1.755
50	24.46	34.74	23.33	0.236	1.663
75	24.42	34.80	23.38	0.350	1.549
100	24.12	34.86	23.52	0.462	1.436
150	18.95	34.82	24.91	0.651	1.248
200	16.05	34.53	25.40	0.796	1.104
250	12.42	34.20	25.91	0.916	0.982
300	10.49	34.16	26.23	1.018	0.881
400	08.24	34.13	26.57	1.188	0.710
500	06.70	34.11	26.78	1.334	0.565
600	06.03	34.18	26.92	1.463	0.436
700	05.69	34.24	27.01	1.581	0.318
800	05.41	34.30	27.09	1.693	0.206
1000	05.03	34.40	27.22	1.899	0.000

STATION 2

M/V Hugh M. Smith: Cruise 1, 18°32'N., 156°15'W., December 18, 1949. Messenger time: 0438 GCT. Weather: scattered clouds, cirrus. Wind: 130°, 4 kt. Sea: 3-5 ft. Wire angle: 45°. Depth of water: 2500 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00		34.40		4.70	
18	24.66	34.32	22.95	4.80	
36	24.63	34.35	22.98	4.87	
70	22.14	34.70	23.97	5.10	
137	18.98	34.61	24.74	4.98	
204	15.17	34.43	25.52	3.82	
271	10.56	34.22	26.26	3.35	
407	07.50	34.14	26.69	1.85	
545	05.94	34.29	27.02	0.95	
687	05.30	34.33	27.13	0.98	
1052	03.90	34.51	27.43	1.52	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	24.71	34.40	23.00	0.000	1.764
10	24.68	34.33	22.95	0.049	1.716
20	24.66	34.32	22.95	0.098	1.666
30	24.64	34.34	22.97	0.147	1.617
50	24.58	34.40	23.04	0.245	1.519
75	21.92	34.70	24.03	0.355	1.410
100	21.02	34.68	24.26	0.450	1.314
150	18.47	34.58	24.85	0.623	1.142
200	15.90	34.47	25.38	0.769	0.996
250	11.99	34.28	26.05	0.886	0.878
300	09.67	34.18	26.39	0.980	0.784
400	07.62	34.14	26.67	1.139	0.626
500	06.39	34.24	26.92	1.272	0.493
600	05.65	34.31	27.07	1.387	0.378
700	05.24	34.34	27.15	1.492	0.273
800	04.83	34.38	27.23	1.590	0.175
1000	04.10	34.48	27.38	1.764	0.000

STATION 3

M/V Hugh M. Smith: Cruise 1, 18°16'N., 156°39'W., December 18, 1949. Messenger time: 0915 GCT. Weather: scattered clouds, form not recorded. Wind: 100°, 3 kt. Sea: 3-5 ft. Wire angle: 00°. Depth of water: 2500 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00		35.07		4.87	
25	24.23	35.08	23.65	4.82	
50	24.26	35.05	23.62	4.72	
100	21.01	35.06	24.55	4.62	
199	18.39	34.93	25.14	4.42	
298	10.93	34.14	26.14	3.68	
398	07.72	34.11	26.63	2.23	
597	05.70	34.29	27.05	0.88	
796	04.73	34.44	27.28	1.01	
995	04.10	34.46	27.37	1.16	
1493	02.75	34.52	27.54	1.74	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	24.30	35.07	23.63	0.000	1.756
10	24.29	35.08	23.64	0.043	1.713
20	24.27	35.08	23.64	0.085	1.671
30	24.27	35.08	23.64	0.128	1.628
50	24.28	35.05	23.62	0.214	1.542
75	22.56	35.08	24.14	0.315	1.441
100	21.03	35.06	24.55	0.406	1.350
150	20.07	35.04	24.79	0.573	1.183
200	18.38	34.93	25.14	0.727	1.029
250	14.45	34.50	25.72	0.859	0.898
300	10.79	34.14	26.16	0.966	0.790
400	07.68	34.11	26.69	1.137	0.619
500	06.54	34.20	26.87	1.274	0.482
600	05.68	34.30	27.06	1.392	0.364
700	05.13	34.40	27.21	1.494	0.262
800	04.68	34.44	27.29	1.586	0.170
1000	04.08	34.46	27.37	1.756	0.000

STATION 4

M/V Hugh M. Smith: Cruise 1, 17°56'N., 157°06'W., December 18, 1949. Messenger time: 1435 GCT. Weather: scattered clouds, form not recorded. Wind: 110°, 3 kt. Sea: 3-5 ft. Wire angle: 05°. Depth of water: 2500 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00		35.09		4.80	
24	24.23	35.06	23.64	4.82	
49	24.28	35.07	23.63	4.82	
98	21.71	35.08	24.38	4.72	
196	18.69	34.95	25.08	4.54	
295	11.00	34.20	26.17	3.66	
394	08.04	34.33 1/	26.76	1.62	
591	05.79	34.35	27.09	0.98	
790	04.90	34.47	27.29	0.96	
988	04.19	34.48	27.38	1.57	
1488	02.82	34.57	27.58	1.88	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	24.24	35.09	23.66	0.000	1.768
10	24.24	35.07	23.64	0.043	1.725
20	24.23	35.06	23.64	0.085	1.682
30	24.24	35.06	23.64	0.128	1.640
50	24.26	35.07	23.64	0.214	1.554
75	23.75	35.08	23.80	0.319	1.444
100	21.68	35.08	24.39	0.416	1.352
150	20.07	35.03	24.78	0.587	1.181
200	18.62	34.94	25.09	0.742	1.026
250	14.90	34.55	25.67	0.876	0.891
300	10.72	34.18	26.21	0.984	0.784
400	07.90	34.11	26.61	1.154	0.613
500	06.60	34.21	26.87	1.293	0.474
600	05.72	34.37	27.11	1.409	0.359
700	05.22	34.45	27.23	1.508	0.260
800	04.85	34.47	27.30	1.598	0.169
1000	04.16	34.48	27.38	1.768	0.000

1/ Value does not fit the T-S curve.

STATION 5

M/V Hugh M. Smith: Cruise 1, 18°20'N., 157°23'W., December 18, 1949. Messenger time: 1920 GCT. Weather: scattered clouds, cirrostratus. Wind: 120°, 3 kt. Sea: 3-5 ft. Wire angle: 15°. Depth of water: 1800 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00		35.12		4.82	
24	24.18	35.05	23.65	4.80	
47	24.14	35.03	23.64	4.84	
94	23.22	35.15	24.00	4.86	
186	18.96	34.96	25.02	4.47	
279	11.54	34.19	26.06	3.96	
372	08.30	34.11	26.55	1.16	
557	05.77	34.34	27.08	0.80	
744	05.16	34.45	27.24	0.86	
932	04.34	34.50	27.37	1.18	
1408	03.04	34.56	27.55	1.62	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	24.16	35.12	23.71	0.000	1.754
10	24.16	35.09	23.68	0.042	1.712
20	24.17	35.06	23.66	0.085	1.670
30	24.16	35.04	23.65	0.127	1.627
50	24.14	35.03	23.64	0.213	1.541
75	24.11	35.10	23.70	0.319	1.435
100	22.85	35.15	24.11	0.420	1.334
150	20.54	35.07	24.69	0.600	1.154
200	18.14	34.89	25.17	0.756	0.998
250	14.13	34.46	25.76	0.886	0.868
300	10.34	34.14	26.24	0.990	0.764
400	07.76	34.11	26.63	1.158	0.596
500	06.27	34.35	27.03	1.288	0.466
600	05.56	34.38	27.14	1.395	0.359
700	05.27	34.43	27.21	1.494	0.260
800	04.98	34.47	27.28	1.586	0.168
1000	04.13	34.51	27.40	1.754	0.000

STATION 6

M/V Hugh M. Smith: Cruise 1, 18°41'N., 156°54'W., December 19, 1949. Messenger time: 0057 GCT. Weather: Rain showers, cloud form not recorded. Wind: 100°, 3 kt. Sea: no observation. Wire angle: 05°. Depth of water: 1400 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00		35.07		4.78	
25	24.31	35.08	23.63	4.82	
50	23.43	35.13	23.93	4.90	
99	20.54	35.07	24.69		
198	14.28	34.49	25.75	4.28	
297	10.70	34.19	26.22	3.54	
396	08.12	34.19	26.64	2.18	
593	05.95	34.36	27.08	1/	
791	04.82	34.45	27.28	0.94	
989	04.04	34.51	27.41	1.20	
1484	02.76	34.56	27.58	1.74	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	24.52	35.07	23.56	0.000	1.657
10	24.43	35.07	23.59	0.043	1.614
20	24.39	35.08	23.60	0.086	1.571
30	24.34	35.09	23.63	0.129	1.528
50	23.33	35.13	23.96	0.212	1.445
75	21.63	35.11	24.42	0.306	1.351
100	20.54	35.07	24.69	0.392	1.265
150	18.26	34.90	25.15	0.547	1.110
200	14.20	34.48	25.76	0.677	0.980
250	11.61	34.26	26.11	0.784	0.873
300	10.65	34.19	26.23	0.880	0.777
400	08.02	34.20	26.66	1.047	0.610
500	06.77	34.30	26.92	1.181	0.476
600	05.88	34.37	27.09	1.296	0.361
700	05.33	34.41	27.19	1.398	0.259
800	04.79	34.45	27.29	1.491	0.166
1000	04.01	34.51	27.42	1.657	0.000

1/ Sample spoiled.

STATION 7

M/V Hugh M. Smith: Cruise 1, 18°55'N., 156°36'W., December 19, 1949. Messenger time: first cast 0620 GCT, second cast 0703 GCT. Weather: no observation. Wind: 010°, 2 kt. Sea: no observation. Wire angle: first cast 23°, second cast 45°. Depth of water: 2500 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00		34.27		4.84	
22	24.78	34.42	22.99	4.78	
45	24.62	34.43	23.04	4.74	
89	21.81	34.90	24.21	5.19	
177	18.06	34.88	25.18	4.54	
266	11.60 1/	34.17	26.04	2.28 3/	
241	11.80 1/	34.17 2/	26.00	3.83	
365	07.77	34.33 2/	26.80	2.25	
493	05.73	34.29	27.05	0.95	
626	05.00	34.43	27.25	1.39	
1128	03.55	34.55	27.49	1.41	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	24.80	34.27	22.87	0.000	1.683
10	24.80	34.37	22.95	0.050	1.633
20	24.76	34.42	23.00	0.099	1.584
30	24.71	34.42	23.00	0.148	1.535
50	24.59	34.44	23.06	0.244	1.438
75	22.60	34.84	23.95	0.355	1.328
100	21.63	34.90	24.26	0.452	1.231
150	19.37	34.92	24.88	0.623	1.060
200	16.38	34.74	25.48	0.766	0.916
250	11.83	34.19	26.01	0.883	0.800
300	09.90	34.14	26.32	0.979	0.704
400	07.05	34.16	26.77	1.136	0.547
500	05.63	34.30	27.07	1.257	0.426
600	05.07	34.42	27.23	1.357	0.325
700	04.75	34.46	27.30	1.447	0.235
800	04.38	34.50	27.37	1.531	0.152
1000	03.74	34.54	27.47	1.683	0.000

1/ Value does not fit the temperature-depth curve.

2/ Value does not fit the temperature-salinity curve.

3/ Value does not fit the oxygen-temperature curve.

STATION 8

M/V Hugh M. Smith: Cruise 1, 19°15'N., 156°06'W., December 19, 1949. Messenger time: 1235 GCT. Weather: overcast (with breaks), cloud form not recorded. Wind: 280°, slight. Sea: < 1 ft. Wire angle: 07°. Depth of water: 1790 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00		34.84		4.90	
25	24.64	34.83	23.34	4.82	
50	24.68	34.92	23.40	4.80	
99	24.12	35.07	23.68	4.84	
196	17.35	34.63	25.16	4.20	
293	11.19	34.18	26.13	3.74	
390	07.80	34.11	26.62	2.66	
585	05.50	34.32	27.10	0.90	
781	04.60	34.43	27.29	1.08	
977	04.06	34.52	27.42	1.26	
1474	02.80	34.61	27.61	1.76	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	24.70	34.84	23.33	0.000	1.790
10	24.68	34.83	23.33	0.046	1.745
20	24.66	34.83	23.34	0.091	1.699
30	24.66	34.84	23.35	0.137	1.654
50	24.68	34.92	23.40	0.227	1.563
75	24.52	35.01	23.51	0.339	1.451
100	24.09	35.07	23.69	0.448	1.343
150	19.91	34.87	24.70	0.637	1.153
200	16.88	34.60	25.25	0.790	1.000
250	13.83	34.35	25.74	0.919	0.872
300	10.81	34.17	26.18	1.026	0.765
400	07.63	34.11	26.65	1.195	0.596
500	06.33	34.22	26.91	1.330	0.461
600	05.38	34.33	27.12	1.442	0.348
700	04.87	34.39	27.23	1.540	0.250
800	04.51	34.45	27.32	1.630	0.161
1000	03.98	34.53	27.44	1.790	0.000

STATION 8-A

M/V Hugh M. Smith: Cruise 1, 19°35'N., 156°11'W., December 14, 1949. Messenger time: 2210 GCT. Weather: scattered clouds, stratocumulus. Wind: 240°, 3 kt. Sea: < 1 ft. Wire angle: 22°. Depth of water: 2000 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00		34.72		3.08	
23	24.48	34.72	23.31	3.24	
46	24.45	34.74	23.33	3.25	
92	24.62	34.96	23.45	3.15	
184	18.86	34.92	25.01	2.82	
275	12.62	34.28	25.93	2.70	
368	08.54	34.14	26.53	1.86	
552	05.06	34.39	27.21	0.69	
923	04.25	34.45	27.34	0.75	
1390	02.96	34.57	27.57	1.10	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	24.67	34.72	23.25	0.000	1.807
10	24.59	34.72	23.27	0.046	1.761
20	24.49	34.72	23.30	0.092	1.714
30	24.46	34.72	23.31	0.138	1.669
50	24.45	34.75	23.34	0.230	1.577
75	24.54	34.89	23.42	0.343	1.464
100	24.64	34.96	23.44	0.456	1.351
150	22.20	35.06	24.23	0.663	1.144
200	18.38	34.87	25.10	0.831	0.975
250	14.38	34.42	25.68	0.965	0.841
300	11.26	34.20	26.12	1.075	0.732
400	07.45	34.17	26.72	1.244	0.563
500	05.51	34.36	27.13	1.364	0.442
600	04.90	34.40	27.23	1.461	0.346
700	04.66	34.42	27.28	1.551	0.256
800	04.48	34.43	27.30	1.638	0.168
1000	04.10	34.46	27.37	1.807	0.000

STATION 8-B

M/V Hugh M. Smith: Cruise 1, 19°14'N., 156°07'W., December 15, 1949. Messenger time: 2042 GCT. Weather: clear. Wind: 100°, 1 kt. Sea: 1-3 ft. Wire angle: 10°. Depth of water: 1750 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00		34.65		3.08	
25	24.48	34.62	23.23	3.14	
49	24.48	34.68	23.28	3.19	
98	24.54	34.87	23.40	3.22	
195	16.04	34.58	25.43	2.74	
292	11.40	34.21	26.11	2.44	
390	07.96	34.14	26.63	1.58	
585	05.54	34.29	27.07	0.60	
781	04.70	34.45	27.29	0.66	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	24.51	34.65	23.25	0.000	1.789
10	24.50	34.63	23.24	0.046	1.743
20	24.49	34.62	23.23	0.093	1.696
30	24.48	34.63	23.24	0.140	1.649
50	24.48	34.69	23.28	0.232	1.557
75	24.73	34.81	23.30	0.348	1.441
100	24.51	34.87	23.41	0.462	1.327
150	18.64	34.80	24.98	0.652	1.137
200	15.82	34.56	25.47	0.793	0.996
250	13.05	34.32	25.88	0.913	0.876
300	11.15	34.20	26.14	1.018	0.772
400	07.71	34.14	26.66	1.188	0.601
500	06.17	34.22	26.94	1.322	0.467
600	05.47	34.30	27.09	1.435	0.354
700	05.05	34.39	27.21	1.536	0.253
800	04.63	34.46	27.30	1.627	0.162
1000	03.98	34.52	27.43	1.789	0.000

STATION 9

M/V Hugh M. Smith: Cruise 1, 19°41'N., 156°20'W., December 19, 1949. Messenger time: 2016 GCT. Weather: scattered clouds, form not recorded. Wind: 310°, 1 kt. Sea: <1 ft. Wire angle: 15°. Depth of water: 1500 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00		34.72		4.86	
24	24.50	34.69	23.28	4.84	
48	24.52	34.75	23.32	4.85	
95	24.51	34.86	23.40	4.82	
188	17.26	34.78	25.30	4.20	
281	11.92	34.23	26.03	4.03	
373	07.79	34.11	26.63	2.84	
373	07.93	34.11	26.61		
558	05.60	34.23	27.01	1.04	
744	04.84 1/	34.40	27.24	1.01	
744	04.58 1/	34.40	27.27		
932	03.95 1/	34.49	27.41	1.18	
932	04.15 1/	34.49	27.39		
1409	03.00	34.55	27.55	1.62	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	24.59	34.72	23.28	0.000	1.811
10	24.52	34.70	23.28	0.046	1.765
20	24.51	34.69	23.28	0.092	1.719
30	24.50	34.70	23.29	0.138	1.673
50	24.50	34.75	23.32	0.230	1.581
75	24.50	34.81	23.37	0.345	1.467
100	24.45	34.87	23.43	0.458	1.353
150	20.23	34.94	24.67	0.655	1.157
200	17.06	34.76	25.33	0.806	1.005
250	13.53	34.37	25.82	0.931	0.880
300	11.12	34.18	26.14	1.037	0.774
400	07.46	34.12	26.68	1.207	0.604
500	06.25	34.18	26.90	1.341	0.470
600	05.35	34.27	27.08	1.457	0.354
700	04.87	34.36	27.21	1.558	0.253
800	04.50	34.43	27.30	1.650	0.162
1000	03.82	34.51	27.43	1.811	0.000

1/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-salinity curve.

STATION 10

M/V Hugh M. Smith: Cruise 1, 19°21'N., 156°46'W., December 20, 1949. Messenger time: first cast 0153 GCT, second cast 0300 GCT. Weather: scattered clouds, form not recorded. Wind: 350°, 2 kt. Sea: <1 ft. Wire angle: first cast 32°, second cast 45°. Depth of water: 2500 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00		34.40		4.90	
20	24.66	34.38	23.00	4.82	
41	24.66	34.38	23.00	4.86	
82	23.03	34.84	23.82	5.10	
164	19.02	34.93	24.98	4.42	
313	09.92	34.17	26.34	3.48	
473	07.05	34.20	26.80	1.49	
637	05.34	34.45	27.22	1.00	
802	04.76	34.46	27.30	1.26	
1231	03.48	34.53	27.48	1.52	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	24.89	34.40	22.94	0.000	1.794
10	24.71	34.39	22.99	0.049	1.745
20	24.66	34.38	23.00	0.098	1.696
30	24.66	34.38	23.00	0.147	1.647
50	24.66	34.41	23.02	0.244	1.550
75	24.50	34.80	23.36	0.362	1.432
100	21.59	34.92	24.29	0.466	1.328
150	19.45	34.93	24.87	0.637	1.157
200	17.47	34.81	25.27	0.785	1.009
250	14.28	34.45	25.72	0.914	0.880
300	10.75	34.18	26.20	1.021	0.774
400	08.13	34.17	26.62	1.190	0.604
500	06.76	34.23	26.87	1.329	0.465
600	05.61	34.41	27.16	1.443	0.351
700	05.06	34.45	27.26	1.539	0.255
800	04.74	34.46	27.30	1.628	0.166
1000	04.07	34.50	27.40	1.794	0.000

STATION 11

M/V Hugh M. Smith: Cruise 1, 19°04'N., 157°13'W., December 20, 1949. Messenger time: 0817 GCT. Weather: scattered clouds, form not recorded. Wind: 020°, 2 kt. Sea: < 1 ft. Wire angle: 08°. Depth of water: 2200 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (μg at/l)
00		34.96		4.96	
24	23.99	35.13	23.76	4.88	
48	23.89	35.13	23.79	4.82	
96	20.99	35.10	24.59	4.74	
191	17.10	34.73	25.30	4.36	
287	10.96	34.20	26.18	3.73	
383	08.07	34.18	26.64	1.68	
574	05.72	34.31	27.06	0.90	
765	04.66 1/	34.42	27.28	0.88	
765	04.82 1/	34.42	27.26		
957	04.05	34.49	27.40	1.18	
1439	02.81	34.56	27.57	1.67	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	24.00	34.96	23.63	0.000	1.676
10	24.00	35.08	23.72	0.042	1.633
20	23.99	35.13	23.76	0.084	1.592
30	23.98	35.13	23.76	0.126	1.550
50	23.86	35.13	23.80	0.208	1.467
75	21.76	35.12	24.39	0.305	1.371
100	20.82	35.10	24.63	0.391	1.284
150	18.94	34.93	25.00	0.551	1.124
200	16.83	34.70	25.34	0.695	0.981
250	12.80	34.31	25.92	0.817	0.859
300	10.22	34.18	26.30	0.916	0.759
400	07.78	34.18	26.68	1.079	0.597
500	06.42	34.26	26.93	1.211	0.464
600	05.53	34.34	27.11	1.323	0.352
700	04.98	34.40	27.23	1.422	0.253
800	04.57	34.45	27.31	1.512	0.163
1000	03.92	34.50	27.42	1.676	0.000

1/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-salinity curve.

STATION 12

M/V Hugh M. Smith: Cruise 1, 18°45'N., 157°36'W., December 20, 1949. Messenger time: 1335 GCT. Weather: scattered clouds, form not recorded. Wind: 060°, 2 kt. Sea: < 1 ft. Wire angle: 35°. Depth of water: 2400 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00		1/			
20	24.17	35.01	23.62	4.80	
41	24.19	35.05	23.64	4.82	
80	24.06	35.05	23.68	4.82	
157	20.58	35.11	24.71	4.82	
230	14.07	34.35	25.69	4.10	
304	10.04	34.18	26.33	3.66	
451	07.42	34.13	26.70	2.10	
598	05.75	34.32	27.07	1.01	
746	05.12	34.43	27.23	1.06	
1114	03.71	34.51	27.45	1.36	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	24.16	35.01	23.62	0.000	1.794
10	24.15	35.01	23.63	0.043	1.751
20	24.15	35.01	23.63	0.086	1.708
30	24.15	35.03	23.64	0.128	1.665
50	24.14	35.05	23.66	0.214	1.580
75	24.08	35.05	23.68	0.320	1.473
100	23.91	35.07	23.74	0.426	1.367
150	20.85	35.11	24.64	0.617	1.177
200	18.03	34.84	25.16	0.774	1.020
250	12.56	34.26	25.93	0.900	0.894
300	10.22	34.18	26.30	0.999	0.795
400	08.05	34.13	26.60	1.165	0.629
500	06.85	34.17	26.81	1.308	0.486
600	05.75	34.32	27.07	1.429	0.365
700	05.27	34.41	27.20	1.531	0.263
800	04.92	34.45	27.27	1.625	0.169
1000	04.09	34.50	27.40	1.794	0.000

1/ No surface sample.

STATION 13

M/V Hugh M. Smith: Cruise 1, 19°14'N., 157°46'W., December 20, 1949. Messenger time: 1855 GCT. Weather: scattered clouds, cumulus. Wind: direction not recorded, 1 kt. Sea: < 1 ft. Wire angle: 14°. Depth of water: 1500 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00		34.97		5.00	
24	24.56	34.92	23.43	4.80	
47	24.56	34.98	23.48	4.74	
95	24.18	35.10	23.69	4.85	
189	19.30	34.96	24.93	4.26	
283	11.89	34.18	26.00	3.81	
377	08.90	34.14	26.48	3.10	
565	05.98	34.28	27.01	1.01	
754	04.98	34.41	27.23	0.98	
944	04.28	34.50	27.38	1.14	
1419	02.98	34.56	27.56	1.62	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D 1000 - \Delta D$ (dyn. m)
00	24.76	34.97	23.41	0.000	1.857
10	24.67	34.94	23.41	0.045	1.812
20	24.56	34.92	23.43	0.090	1.767
30	24.55	34.93	23.45	0.134	1.723
50	24.53	34.99	23.49	0.223	1.634
75	24.38	35.05	23.59	0.333	1.524
100	24.07	35.11	23.73	0.440	1.417
150	21.08	35.10	24.57	0.632	1.225
200	18.90	34.93	25.01	0.794	1.062
250	16.20	34.62	25.43	0.936	0.920
300	11.13	34.16	26.12	1.052	0.805
400	08.41	34.14	26.56	1.230	0.627
500	06.78	34.18	26.83	1.374	0.483
600	05.66	34.32	27.08	1.493	0.364
700	05.20	34.38	27.18	1.596	0.261
800	04.79	34.44	27.28	1.689	0.167
1000	04.09	34.51	27.41	1.857	0.000

STATION 14

M/V Hugh M. Smith: Cruise 1, 19°26'N., 157°34'W., December 20, 1949. Messenger time: first cast 2255 GCT, second cast 2330 GCT. Weather: scattered clouds, cumulus. Wind: 020°, slight. Sea: < 1 ft. Wire angle: first cast 45°, second cast no observation. Depth of water: 1500 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00		34.95		4.86	
18	24.39	34.99	23.54	5.04	
35	24.12	35.11	23.71	4.86	
69	24.08	35.13	23.74	4.70	
136	21.54	35.12	24.45	4.62	
201	19.09	35.01	25.02	4.62	
280	12.32	34.25	25.96	3.52	
401	08.33	35.02 1/	27.26	2.23	
538	06.20	34.22	26.93	1.08	
681	05.06	34.34	27.17	0.90	
1061	03.86	34.51	27.43	1.31	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	24.59	34.95	23.45	0.000	1.837
10	24.43	34.96	23.51	0.044	1.792
20	24.37	35.00	23.55	0.088	1.749
30	24.19	35.09	23.67	0.131	1.706
50	24.10	35.12	23.72	0.215	1.621
75	24.09	35.13	23.74	0.321	1.516
100	23.94	35.13	23.78	0.425	1.411
150	20.95	35.11	24.61	0.615	1.221
200	19.14	35.01	25.01	0.776	1.060
250	16.40	34.63	25.39	0.920	0.917
300	11.18	34.20	26.14	1.036	0.801
400	08.37	34.13	26.56	1.212	0.624
500	06.62	34.19	26.85	1.355	0.482
600	05.63	34.27	27.04	1.474	0.362
700	04.97	34.36	27.20	1.578	0.258
800	04.58	34.42	27.29	1.671	0.166
1000	03.98	34.50	27.41	1.837	0.000

1/ Value does not fit the T-S curve.

STATION 15

M/V Hugh M. Smith: Cruise 1, 19°36'N., 157°06'W., December 21, 1949. Messenger time: 0555 GCT. Weather: scattered clouds, cumulus. Wind: 320°, 2 kt. Sea: < 1 ft. Wire angle: no observation. Depth of water: 2500 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00		34.43		4.82	
25	24.67	34.38	22.99	4.84	
50	24.70	1/		4.80	
99	22.78	34.81	23.87	5.15	
196	18.06	34.80	25.12	4.32	
292	11.03	34.21	26.17	3.52	
387	08.53	34.19	26.58	2.42	
579	05.67	34.30	27.06	1.04	
770	04.57	34.45	27.31	0.88	
962	03.95	34.51	27.42	1.23	
1445	02.80	34.53	27.55	2.00	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	24.80	34.43	22.99	0.000	1.821
10	24.74	34.39	22.98	0.049	1.772
20	24.70	34.38	22.98	0.098	1.723
30	24.68	34.39	23.00	0.147	1.674
50	24.68	34.50	23.08	0.244	1.577
75	24.68	34.67	23.21	0.363	1.458
100	22.68	34.81	23.90	0.472	1.348
150	20.08	34.92	24.70	0.657	1.164
200	17.99	34.79	25.13	0.813	1.008
250	13.92	34.36	25.73	0.945	0.876
300	10.78	34.20	26.21	1.051	0.770
400	08.27	34.19	26.62	1.221	0.600
500	06.68	34.22	26.87	1.360	0.461
600	05.51	34.32	27.10	1.476	0.345
700	04.90	34.41	27.24	1.575	0.246
800	04.43	34.46	27.33	1.663	0.158
1000	03.80	34.52	27.45	1.821	0.000

1/ Sample lost.

STATION 16

M/V Hugh M. Smith: Cruise 1, 20°07'N., 156°25'W., December 21, 1949. Messenger time: 1312 GCT. Weather: clear. Wind: 330°, 3 kt. Sea: 1-3 ft. Wire angle: 55°. Depth of water: 1000 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00		34.60		4.90	
15	24.33	34.53	23.21	4.85	
30	24.32	34.69	23.33	4.78	
56	23.33	35.03	23.88	4.84	
106	21.86	35.17	24.40	4.90	
156	20.32	35.12	24.79	4.59	
206	18.13	34.85	25.15	5.38	
314	10.89	34.20	26.19	3.73	
425	07.56	34.17	26.71	2.26	
544	06.18	34.23	26.94	1.04	
871	04.40	34.43	27.31	1.21	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	24.34	34.60	23.26	0.000	1.823
10	24.32	34.54	23.22	0.046	1.776
20	24.32	34.54	23.22	0.093	1.730
30	24.30	34.69	23.34	0.139	1.684
50	24.29	35.00	23.58	0.228	1.594
75	24.08	35.08	23.70	0.336	1.487
100	22.50	35.16	24.22	0.436	1.387
150	20.39	35.13	24.77	0.611	1.212
200	18.52	34.91	25.09	0.766	1.057
250	15.62	34.54	25.50	0.905	0.918
300	11.62	34.22	26.07	1.020	0.803
400	07.95	34.17	26.65	1.195	0.628
500	06.61	34.20	26.86	1.332	0.490
600	05.77	34.28	27.03	1.452	0.371
700	05.18	34.35	27.16	1.558	0.265
800	04.68	34.41	27.27	1.653	0.170
1000	04.00	34.48	27.39	1.823	0.000

STATION 1

M/V Hugh M. Smith: Cruise 10, 20°18'N., 159°20'W., July 21, 1951. Messenger time: 1820 GCT. Weather: 02, cloud coverage 6. Wind: 060°, 16 kt. Sea: 5-8 ft. Wire angle: 42°. Depth of water: 2500 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.90	34.65	22.81	4.65	
08	25.94	34.65	22.81	4.66	
22	25.94	1/		4.70	
42	26.05	34.74	22.84	4.69	
80	25.36	34.79	23.09	4.96	
146	21.18	1/			
210	17.64	34.87	25.28	4.70	
270	11.96	34.23	26.02	4.28	
332	08.79	34.04	26.42	3.77	
393	08.19	34.17	26.62	2.30	
520	06.33	2/			
659	05.37	34.35	27.14	0.96	
823	04.64	2/		1.79	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	25.93	34.65	22.81	0.000	1.845
10	25.94	34.65	22.80	0.051	1.794
20	25.94	34.68	22.83	0.101	1.744
30	25.98	34.71	22.84	0.151	1.694
50	26.04	34.76	22.86	0.252	1.593
75	25.97	34.79	22.90	0.377	1.468
100	23.30	35.05	23.90	0.490	1.355
150	20.99	35.15	24.63	0.676	1.169
200	18.25	34.93	25.17	0.832	1.013
250	14.10	34.47	25.77	0.961	0.884
300	09.90	34.06	26.25	1.064	0.781
400	08.11	34.18	26.63	1.230	0.615
500	06.62	34.28	26.92	1.365	0.480
600	05.72	34.33	27.08	1.479	0.366
700	05.18	34.37	27.17	1.581	0.264
800	04.72	34.40	27.25	1.676	0.169
1000	03.92	34.46	27.38	1.845	0.000

1/ Sample lost. Bottle tripped accidentally.

2/ Value did not fit the temperature-salinity curve.

STATION 2

M/V Hugh M. Smith: Cruise 10, 21°03'N., 159°14'W., July 22, 1951. Messenger time: 0211 GCT. Weather: not recorded. Wind: 020° 14 kt. Sea: not recorded. Wire angle: 00°. Depth of water: 2500 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
04	26.60	34.77	22.69	4.75	
20	26.48	34.78	22.74	4.75	
40	26.49	34.77	22.73	4.75	
80	23.60	35.01	23.79	5.16	
155	19.76	35.06	24.89	4.56	
300	10.74	34.18	26.20	4.26	
438	07.02	34.01	26.66	2.64	
586	05.64	34.23	27.01	1.09	
725	05.00	34.34	27.18	0.95	
874	04.40	34.42	27.30	1.06	
1163	03.61	1/			
1454	02.96	34.51	27.52	1.68	
1753	02.42	34.57	27.61	1.96	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	26.61	34.77	22.69	0.000	1.844
10	26.59	34.77	22.69	0.052	1.792
20	26.48	34.78	22.73	0.103	1.741
30	26.48	34.78	22.73	0.155	1.689
50	26.49	34.78	22.73	0.257	1.587
75	24.02	34.97	23.63	0.375	1.469
100	22.64	35.12	24.14	0.477	1.367
150	19.95	35.07	24.84	0.651	1.193
200	17.83	34.87	25.23	0.801	1.043
250	14.13	34.49	25.78	0.928	0.916
300	10.74	34.18	26.20	1.033	0.811
400	07.73	34.01	26.55	1.205	0.639
500	06.35	34.07	26.79	1.349	0.495
600	05.57	34.24	27.02	1.471	0.373
700	05.11	34.33	27.15	1.577	0.267
800	04.71	34.38	27.23	1.673	0.171
1000	03.94	34.46	27.38	1.844	0.000

1/ Value did not fit the temperature-salinity curve.

STATION 3

M/V Hugh M. Smith: Cruise 10, 21°44'N., 159°13'W., July 22, 1951. Messenger time: 0905 GCT. Weather: 03, cloud coverage not recorded. Wind: 060°, 15 kt. Sea: 3-5 ft. Wire angle: 30°. Depth of water: 1850 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.90	34.88	23.01	4.86	
10	25.86	34.86	22.99	4.82	
27	25.42	34.88	23.15	4.80	
51	23.75	35.02	23.75	5.25	
100	21.88	35.17	24.40	5.02	
197	17.81	34.84	25.22	4.54	
294	12.72	34.27	25.90	4.54	
387	08.82	34.08	26.45	3.71	
485	06.81	33.99	26.67	2.26	
578	05.53	34.14	26.95	1.29	
767	04.54	1/			
958	04.12	34.44	27.35	1.24	
1156	03.53	1/		1.26	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	25.86	34.88	23.00	0.000	1.832
10	25.86	34.86	22.99	0.049	1.783
20	25.86	34.87	23.00	0.098	1.734
30	25.17	34.89	23.22	0.145	1.687
50	23.77	35.02	23.74	0.234	1.598
75	22.64	35.13	24.15	0.334	1.498
100	21.88	35.17	24.40	0.426	1.406
150	20.49	35.11	24.73	0.597	1.235
200	17.68	34.83	25.23	0.749	1.083
250	15.78	34.60	25.50	0.883	0.949
300	12.34	34.25	25.96	1.000	0.832
400	08.52	34.07	26.48	1.188	0.644
500	06.60	34.00	26.70	1.340	0.492
600	05.34	34.19	27.01	1.467	0.365
700	04.78	34.34	27.19	1.570	0.262
800	04.49	34.39	27.27	1.662	0.170
1000	04.01	34.45	27.36	1.832	0.000

1/ Value did not fit the temperature-salinity curve.

STATION 4

M/V Hugh M. Smith: Cruise 10, 22°22'N., 159°15'W., July 22, 1951. Messenger time: 1635 GCT. Weather: 01, cloud coverage 5. Wind: 040°, 13 kt. Sea: 3-5 ft. Wire angle: 32°. Depth of water: 1250 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.60	34.82	23.04	4.82	
09	25.60	34.83	23.05	4.86	
26	25.62	34.85	23.06	4.84	
50	25.44	34.87	23.13	4.94	
99	23.17	35.08	23.97	5.11	
187	19.56	35.05	24.93	4.55	
271	13.71	34.33	25.75	4.52	
352	10.06	34.06	26.23	4.30	
439	07.57	34.02	26.59	2.85	
525	06.38	34.03	26.76	1.98	
701	04.88	1/			
888	04.24	34.41	27.31	0.99	
1077	03.68	1/			

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	25.59	34.82	23.04	0.000	1.910
10	25.60	34.83	23.05	0.048	1.862
20	25.61	34.84	23.05	0.097	1.813
30	25.62	34.85	23.05	0.145	1.765
50	25.44	34.87	23.12	0.241	1.669
75	24.06	35.00	23.64	0.354	1.556
100	23.14	35.09	23.98	0.457	1.453
150	21.10	35.19	24.63	0.641	1.269
200	19.32	35.02	24.97	0.802	1.108
250	16.00	34.61	25.46	0.943	0.967
300	12.03	34.19	25.97	1.061	0.849
400	08.50	34.03	26.45	1.249	0.661
500	06.66	34.02	26.71	1.403	0.507
600	05.65	34.13	26.93	1.533	0.377
700	04.90	34.27	27.13	1.644	0.266
800	04.52	34.35	27.23	1.742	0.168
1000	03.91	34.50	27.41	1.910	0.000

1/ Value did not fit the temperature-salinity curve.

STATION 5

M/V Hugh M. Smith: Cruise 10, 23°02'N., 159°15'W., July 22, 1951. Messenger time: 2311 GCT. Weather: 01, cloud coverage 4. Wind: 040°, 16 kt. Sea: 3-5 ft. Wire angle: 27°. Depth of water: 2600 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
01	25.90	34.80	22.93	4.87	
09	25.89	34.79	22.93	4.86	
28	25.80	34.85	23.00	4.85	
54	25.11	34.85	23.22	5.05	
108	23.32	35.06	23.91	5.11	
213	19.20	35.07	25.04	4.57	
316	13.14	34.34	25.87	4.42	
414	08.89	34.13	26.48	4.04	
516	06.83	34.02	26.69	2.23	
615	05.52	34.12	26.94	1.08	
818	04.52	1/			
1020	03.86	34.59	27.50	1.24	
1228	03.38	34.56	27.52	2.99	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	25.91	34.80	22.93	0.000	1.974
10	25.88	34.79	22.93	0.049	1.925
20	25.86	34.84	22.97	0.099	1.875
30	25.79	34.85	23.00	0.148	1.826
50	25.73	34.85	23.02	0.245	1.729
75	24.53	34.90	23.42	0.362	1.612
100	23.56	35.03	23.81	0.470	1.504
150	21.90	35.18	24.40	0.663	1.311
200	19.80	35.12	24.92	0.831	1.143
250	17.06	34.81	25.37	0.976	0.998
300	14.00	34.43	25.76	1.101	0.873
400	09.28	34.15	26.42	1.301	0.673
500	07.10	34.02	26.65	1.459	0.515
600	05.72	34.09	26.89	1.595	0.379
700	05.00	34.24	27.09	1.710	0.264
800	04.61	34.35	27.22	1.809	0.165
1000	03.96	34.57	27.47	1.974	0.000

1/ Value did not fit the temperature-salinity curve.

STATION 6

M. V Hugh M. Smith: Cruise 10, 22°48'N., 158°25'W., July 23, 1951. Messenger time: 0738 GCT. Weather: not recorded. Wind: not recorded. Sea: not recorded. Wire angle: 14°. Depth of water: 2600 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.70	34.86	23.03	4.87	
10	25.74	34.87	23.04	4.88	
30	25.73	34.85	23.03	4.88	
58	25.73	34.87	23.04	4.90	
118	21.94	1/		4.99	
232	17.84	34.86	25.22	4.50	
342	11.26	34.10	26.05	4.45	
448	07.68	34.03	26.58	3.28	
561	06.36	34.15	26.86	1.35	
669	05.10	34.24	27.08	0.84	
892	04.43	34.43	27.31	1.22	
1110	03.75	34.47	27.41	1.33	
1321	03.26	34.47	27.46	1.51	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	25.73	34.86	23.03	0.000	1.953
10	25.74	34.87	23.03	0.048	1.905
20	25.74	34.86	23.02	0.097	1.856
30	25.73	34.85	23.02	0.145	1.808
50	25.73	34.86	23.03	0.243	1.710
75	25.73	34.87	23.04	0.364	1.589
100	23.16	35.07	23.96	0.475	1.478
150	20.72	35.17	24.71	0.657	1.296
200	19.03	35.01	25.04	0.814	1.139
250	17.13	34.76	25.31	0.958	0.995
300	14.22	34.38	25.68	1.086	0.867
400	08.82	34.04	26.41	1.291	0.662
500	06.78	34.11	26.76	1.444	0.509
600	05.64	34.19	26.97	1.570	0.383
700	04.97	34.26	27.11	1.680	0.273
800	04.69	34.36	27.22	1.778	0.175
1000	04.11	34.46	27.36	1.953	0.000

1/ Sample lost.

STATION 7

M/V Hugh M. Smith: Cruise 10, 22°08'N., 158°24'W., July 23, 1951. Messenger time: 1355 GCT. Weather: 02, cloud coverage 8. Wind: not recorded. Sea: not recorded. Wire angle: 21°. Depth of water: 2700 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
01	25.80	34.65	22.85	4.85	
11	25.86	34.66	22.84	4.85	
29	25.86	34.65	22.84	4.84	
57	25.02	34.94	23.31	5.09	
114	22.26	35.15	24.28	4.81	
226	18.09	34.88	25.18	4.63	
339	10.71	34.14	26.18	3.82	
446	07.85	34.04	26.56	3.15	
559	05.90	34.08	26.86	1.70	
667	04.93	34.19	27.06	0.84	
890	04.16	34.44	27.35	1.41	
1105	03.66	34.47	27.42	1.35	
1316	03.12	1/		1.51	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	25.83	34.65	22.84	0.000	1.923
10	25.86	34.66	22.84	0.050	1.873
20	25.86	34.66	22.84	0.101	1.822
30	25.86	34.65	22.83	0.151	1.772
50	25.54	34.82	23.06	0.250	1.673
75	24.00	35.04	23.69	0.363	1.560
100	22.93	35.13	24.07	0.465	1.458
150	20.54	35.13	24.73	0.644	1.279
200	18.91	34.98	25.04	0.800	1.123
250	17.00	34.75	25.34	0.943	0.980
300	13.22	34.30	25.82	1.068	0.855
400	08.84	34.09	26.45	1.264	0.659
500	06.86	34.03	26.69	1.418	0.505
600	05.48	34.12	26.94	1.549	0.374
700	04.79	34.23	27.11	1.660	0.263
800	04.41	34.39	27.27	1.756	0.167
1000	03.89	34.46	27.39	1.923	0.000

1/ Value did not fit the temperature-salinity curve.

STATION 8

M/V Hugh M. Smith: Cruise 10, 21°29'N., 158°25'W., July 23, 1951. Messenger time: 2044 GCT. Weather: 01, cloud coverage 9. Wind: not recorded. Sea: < 1 ft. Wire angle: 02°. Depth of water: 1350 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.20	34.64	22.71	4.80	
10	26.06	34.57	22.71	4.78	
25	26.00	34.58	22.74	4.82	
56	24.98	34.42	22.93	4.99	
111	22.83	34.91	23.94	5.06	
219	17.26	34.77	25.29	4.51	
327	10.56	34.12	26.19	4.27	
437	07.91 1/	34.17	26.65	2.09	
437	07.97 1/	34.17	26.65		
543	06.55	34.22	26.89	1.24	
647	05.51	34.27	27.06	1.05	
855	04.48	34.40	27.28	1.34	
1065	03.88	34.51	27.43	1.33	
1267	03.38	34.50	27.47	2.92	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	26.23	34.64	22.71	0.000	1.935
10	26.06	34.57	22.71	0.052	1.883
20	26.04	34.58	22.72	0.103	1.832
30	25.99	34.57	22.73	0.154	1.781
50	25.12	34.44	22.90	0.256	1.679
75	24.47	34.48	23.12	0.378	1.557
100	23.52	34.70	23.57	0.492	1.443
150	21.45	35.04	24.42	0.690	1.245
200	18.43	34.91	25.11	0.853	1.082
250	15.07	34.49	25.58	0.988	0.947
300	11.91	34.20	26.00	1.102	0.833
400	08.64	34.14	26.52	1.286	0.649
500	07.04	34.20	26.80	1.432	0.503
600	05.95	34.25	26.98	1.556	0.379
700	05.21	34.30	27.11	1.666	0.269
800	04.71	34.37	27.23	1.764	0.171
1000	03.99	34.49	27.40	1.935	0.000

1/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-salinity curve.

STATION 8-A

M/V Hugh M. Smith: Cruise 10, 21°26'N., 158°25'W., July 19, 1951. Messenger time: 2333 GCT. Weather: 02, cloud coverage 4. Wind: 040°, 14 kt. Sea: 1-3 ft. Wire angle: 07°. Depth of water: 1300 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.20	34.78	22.84	5.00	
10	26.14	34.80	22.86	4.84	
30	26.08	1/		4.86	
61	24.36	34.89	23.47	5.09	
118	22.12	1/		4.97	
235	17.30	1/			
350	09.98	34.12	26.29	4.24	
461	07.42	34.16	26.72	1.83	
578	05.78	34.25	27.01	1.16	
690	05.05	1/		1.22	
919	04.25	2/			
1141	03.60	34.53	27.47	1.33	
1353	03.16	2/			

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	26.17	34.78	22.83	0.000	1.877
10	26.14	34.80	22.86	0.050	1.827
20	26.11	34.81	22.87	0.100	1.777
30	26.08	34.82	22.89	0.150	1.727
50	25.15	34.83	23.18	0.247	1.630
75	23.62	34.98	23.75	0.358	1.519
100	22.46	35.13	24.20	0.458	1.419
150	20.67	35.13	24.70	0.634	1.243
200	18.86	34.96	25.04	0.792	1.085
250	16.59	34.71	25.40	0.933	0.944
300	13.05	34.35	25.89	1.054	0.823
400	08.59	34.13	26.52	1.243	0.634
500	06.83	34.19	26.82	1.388	0.489
600	05.60	34.27	27.04	1.508	0.369
700	05.02	34.33	27.16	1.612	0.265
800	04.63	34.38	27.24	1.708	0.169
1000	04.01	34.49	27.40	1.877	0.000

1/ Sample lost. Nansen bottle leaked.

2/ Value did not fit the temperature-salinity curve.

STATION 9

M/V Hugh M. Smith: Cruise 10, 20°50'N., 158°25'W., July 23, 1951. Messenger time: 0850 GCT. Weather: not recorded. Wind: direction not recorded, 22 kt. Sea: not recorded. Wire angle: 58°. Depth of water: 2350 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.20	34.63	22.70	4.83	
10	26.26	34.60	22.67	4.79	
20	26.24	34.60	22.68	4.79	
42	25.90	34.75	22.90	4.92	
81	24.22	34.92	23.54	5.18	
151	20.02	35.00	24.78	4.86	
210	14.66	34.42	25.62	4.17	
269	10.36	34.17	26.26	3.42	
330	08.78	34.19	26.54	2.43	
387	07.88	34.23	26.71	2.02	
503	06.42	34.37	27.02	2.29	
617	05.72	34.35	27.10	0.86	
775	05.08	34.44	27.25	1/	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	26.24	34.63	22.70	0.000	1.777
10	26.26	34.60	22.67	0.052	1.725
20	26.24	34.60	22.67	0.104	1.673
30	26.16	34.63	22.72	0.155	1.622
50	25.80	34.77	22.94	0.256	1.521
75	24.47	34.90	23.44	0.374	1.403
100	23.16	34.98	23.89	0.481	1.296
150	20.40	35.01	24.68	0.665	1.112
200	15.71	34.55	25.48	0.813	0.964
250	11.30	34.19	26.11	0.926	0.851
300	09.42	34.17	26.42	1.017	0.760
400	07.71	34.24	26.74	1.170	0.607
500	06.48	34.36	27.00	1.295	0.482
600	05.81	34.34	27.07	1.405	0.372
700	05.34	34.39	27.17	1.508	0.269
800	05.00	34.45	27.26	1.603	0.174
1000	04.50	34.49	27.34	1.777	0.000

1/ Sample spoiled.

STATION 10

M/V Hugh M. Smith: Cruise 10, 20°17'N., 158°21'W., July 24, 1951. Messenger time: 1733 GCT. Weather: not recorded. Wind: 060°, 12 kt. Sea: not recorded. Wire angle: 42°. Depth of water: 2520 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.30	34.88	22.88	5.03	
07	26.26	34.92	22.91	4.81	
21	26.28	34.92	22.90	4.85	
41	24.10	34.97	23.61	5.16	
79	20.50	35.01	24.65	4.97	
156	14.84	34.48	25.63	4.15	
233	10.64	34.16	26.21	4.12	
307	08.65	34.14	26.52	2.62	
383	07.28	34.17	26.75	2.09	
454	06.55	34.22	26.89	1.18	
608	05.56	34.39	27.15	1.19	
776	04.94	34.41	27.24	1.01	
962	04.21	34.44	27.34	1.22	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	26.26	34.88	22.88	0.000	1.586
10	26.26	34.92	22.91	0.050	1.536
20	26.28	34.92	22.90	0.099	1.487
30	26.28	34.93	22.91	0.149	1.437
50	22.56	35.01	24.08	0.237	1.349
75	20.79	35.02	24.58	0.328	1.258
100	19.01	34.93	24.98	0.408	1.178
150	15.30	34.54	25.57	0.545	1.041
200	12.07	34.23	25.99	0.658	0.928
250	10.03	34.16	26.31	0.754	0.832
300	08.80	34.15	26.50	0.838	0.748
400	07.08	34.19	26.79	0.984	0.602
500	06.26	34.26	26.95	1.110	0.476
600	05.63	34.39	27.13	1.219	0.367
700	05.20	34.40	27.19	1.317	0.269
800	04.84	34.41	27.24	1.411	0.175
1000	04.14	34.44	27.34	1.586	0.000

STATION 11

M/V Hugh M. Smith: Cruise 10, 18°45'N., 157°30'W., July 25, 1951. Messenger time: 0646 GCT. Weather: 01, cloud coverage not recorded. Wind: 070°, 16 kt. Sea: 1-3 ft. Wire angle: 32°. Depth of water: 2425 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.90	34.61	22.80	4.86	
09	25.86	34.61	22.80	4.85	
27	25.88	34.61	22.80	4.84	
51	25.72	34.59	22.83	4.87	
101	25.48	34.65	22.95	4.94	
194	20.76	35.11	24.66	4.88	
282	12.24	34.21	25.95	3.52	
367	09.01 1/	34.14	26.46	2.79	
367	09.07 1/	34.14	26.45		
456	07.25	34.14	26.73	1.77	
541	06.46	34.28	26.95	0.93	
719	05.44	34.46	27.22	1.03	
901	04.48	34.50	27.36	1.04	
1090	04.04	2/		0.92	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	25.86	34.61	22.80	0.000	1.976
10	25.86	34.61	22.80	0.051	1.925
20	25.87	34.61	22.80	0.101	1.875
30	25.88	34.61	22.79	0.152	1.824
50	25.75	34.59	22.82	0.253	1.723
75	25.64	34.60	22.86	0.380	1.596
100	25.49	34.65	22.94	0.505	1.471
150	23.45	35.01	23.83	0.732	1.244
200	20.24	35.06	24.76	0.917	1.059
250	15.13	34.50	25.57	1.061	0.915
300	11.28	34.18	26.10	1.173	0.803
400	08.36	34.14	26.56	1.350	0.626
500	06.81	34.20	26.83	1.492	0.484
600	06.11	34.35	27.04	1.612	0.364
700	05.58	34.44	27.18	1.716	0.260
800	05.02	34.49	27.29	1.809	0.167
1000	04.14	34.50	27.39	1.976	0.000

1/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-salinity curve.

2/ Value did not fit the temperature-salinity curve.

STATION 12

M/V Hugh M. Smith: Cruise 10, 19°32'N., 157°28'W., July 25, 1951. Messenger time: 1435 GCT. Weather: 03, cloud coverage 10. Wind: 240°, 4 kt. Sea: 1-3 ft. Wire angle: 11°. Depth of water: 2360 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.00	34.66	22.79	4.84	
11	25.95	34.64	22.80	4.85	
29	25.84	34.65	22.84	4.86	
60	25.37	34.67	23.00	4.86	
118	23.25	35.04	23.91	5.15	
235	16.36	34.61	25.38	4.35	
349	09.76	34.17	26.36	2.99	
459	07.86	34.29	26.76	1.34	
574	06.34	34.27	26.96	0.74	
683	05.90	34.40	27.11	0.70	
909	04.71	34.50	27.33	1.14	
1129	03.97	34.51	27.42	1.16	
1343	03.40	34.51	27.48	1.51	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	26.01	34.66	22.79	0.000	1.944
10	25.96	34.64	22.79	0.051	1.893
20	25.91	34.64	22.81	0.101	1.843
30	25.84	34.65	22.84	0.152	1.792
50	25.56	34.66	22.93	0.252	1.692
75	25.25	34.69	23.05	0.374	1.570
100	24.83	34.77	23.24	0.494	1.450
150	21.32	35.12	24.51	0.698	1.246
200	17.85	34.80	25.17	0.856	1.088
250	15.62	34.53	25.49	0.992	0.952
300	12.44	34.24	25.93	1.111	0.833
400	08.76	34.23	26.57	1.296	0.648
500	07.30	34.27	26.82	1.438	0.506
600	06.22	34.30	26.99	1.562	0.382
700	05.83	34.41	27.12	1.671	0.273
800	05.31	34.47	27.24	1.770	0.174
1000	04.34	34.50	27.37	1.944	0.000

STATION 13

M/V Hugh M. Smith: Cruise 10, 20°07'N., 157°28'W., July 25, 1951. Messenger time: 2014 GCT. Weather: 01, cloud coverage 5. Wind: 040°, 19 kt. Sea: 1-3 ft. Wire angle: 31°. Depth of water: 2260 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
01	25.90	34.67	22.85	4.82	
11	25.88	34.64	22.82	4.86	
29	25.88	34.65	22.83	4.83	
56	25.86	34.64	22.82	4.84	
110	24.90	34.60	23.09	4.97	
215	16.83	34.63	25.29	4.15	
320	10.08	34.17	26.31	3.14	
420	08.37	34.25	26.65	1.71	
524	06.79	34.22	26.86	1.08	
625	06.19	34.35	27.04	0.70	
833	04.88	34.48	27.30	1.27	
1041	04.12	34.49	27.39	1.38	
1247	03.52	34.51	27.47	1.42	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	25.87	34.68	22.85	0.000	1.939
10	25.88	34.64	22.82	0.050	1.889
20	25.88	34.64	22.82	0.101	1.838
30	25.88	34.65	22.82	0.151	1.788
50	25.86	34.65	22.83	0.252	1.687
75	25.84	34.63	22.82	0.379	1.560
100	25.22	34.58	22.97	0.504	1.435
150	22.39	35.07	24.18	0.722	1.217
200	18.07	34.78	25.10	0.891	1.048
250	13.88	34.33	25.71	1.023	0.916
300	10.67	34.18	26.21	1.129	0.810
400	08.72	34.23	26.58	1.300	0.639
500	07.08	34.21	26.80	1.443	0.496
600	06.34	34.32	26.99	1.567	0.372
700	05.68	34.43	27.16	1.675	0.264
800	05.06	34.48	27.27	1.769	0.170
1000	04.29	34.50	27.37	1.939	0.000

STATION 14

M/V Hugh M. Smith: Cruise 10, 20°43'N., 157°29'W., July 26, 1951. Messenger time: 0137 GCT. Weather: 01, cloud coverage 3. Wind: 080°, 14 kt. Sea: 1-3 ft. Wire angle: 12°. Depth of water: 1500 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.20	34.60	22.69	4.82	
10	26.02	34.61	22.76	4.84	
29	25.98	34.61	22.76	4.87	
59	25.38	34.54	22.90	4.92	
115	22.70	35.01	24.05	5.01	
224	15.90	34.54	25.43	4.18	
333	09.66	34.20	26.41	2.82	
438	07.74	34.16	26.67	1.83	
547	06.30	34.25	26.95	1.25	
653	05.49	34.35	27.12	0.87	
872	04.74	34.49	27.32	1.21	
1086	03.88	34.50	27.42	1.24	
1300	03.29	34.49	27.47	2.09	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	26.20	34.60	22.69	0.000	1.879
10	26.02	34.61	22.75	0.051	1.828
20	26.00	34.61	22.76	0.103	1.776
30	25.98	34.61	22.76	0.154	1.725
50	25.69	34.57	22.82	0.255	1.624
75	24.56	34.66	23.23	0.377	1.502
100	23.66	34.83	23.63	0.489	1.390
150	20.98	35.10	24.59	0.682	1.197
200	17.90	34.77	25.13	0.840	1.039
250	14.12	34.36	25.68	0.972	0.907
300	11.00	34.19	26.16	1.080	0.799
400	08.37	34.18	26.59	1.252	0.627
500	06.83	34.20	26.83	1.393	0.486
600	05.80	34.31	27.05	1.513	0.366
700	05.29	34.39	27.17	1.616	0.263
800	04.97	34.46	27.27	1.710	0.169
1000	04.20	34.50	27.38	1.879	0.000

STATION 15

M/V Hugh M. Smith: Cruise 10, 21°02'N., 157°29'W., July 26, 1951. Messenger time: 0524 GCT. Weather: 01, cloud coverage 4. Wind: 020°, 22 kt. Sea: 1-3 ft. Wire angle: 00°. Depth of water: 30 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.00	34.57	22.72	4.91	
10	26.08	34.61	22.74	4.92	
25	26.00	34.62	22.77	4.92	
35	25.83	34.58	22.79	4.88	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	26.05	34.57			
10	26.08	34.61			
20	26.05	34.62			
30	25.94	34.61			

STATION 16

M/V Hugh M. Smith: Cruise 10, 21°17'N., 157°26'W., July 26, 1951. Messenger time: 0840 GCT. Weather: 01, cloud coverage not recorded. Wind: 040°, 28 kt. Sea: 5-8 ft. Wire angle: 12°. Depth of water: 336 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.60	34.56	22.86	4.95	
10	25.58	34.61	22.89	4.93	
24	25.58	34.57	22.86	4.92	
48	25.58	34.61	22.89	4.93	
96	23.36	34.99	23.84	5.12	
192	17.56	34.82	25.26	4.59	
287	12.41	34.24	25.94	3.99	
383	09.33 1/	34.11	26.39	3.74	
383	09.39 1/	34.11	26.38		
479	06.75	34.11	26.77	2.18	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	25.57	34.56			
10	25.58	34.61			
20	25.58	34.58			
30	25.58	34.57			
50	25.58	34.62			
75	24.35	34.85			
100	23.27	35.00			
150	21.17	35.19			
200	17.10	34.76			
250	13.96	34.36			
300	11.95	34.21			
400	08.93	34.11			

1/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-salinity curve.

STATION 17

M/V Hugh M. Smith: Cruise 10, 21°45'N., 157°29'W., July 26, 1951. Messenger time: 1340 GCT. Weather: 22, cloud coverage not recorded. Wind: 040°, 18 kt. Sea: 3-5 ft. Wire angle: 15°. Depth of water: 1600 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.80	34.65	22.87	4.85	
10	25.76	34.65	22.87	4.86	
25	25.68	34.78	22.99	4.88	
53	25.48	34.84	23.09	4.88	
104	22.47	35.19	24.25	5.16	
200	18.68	34.97	25.10	4.64	
292	12.35	34.17	25.90	4.42	
389	08.93 1/	34.13	26.47	3.06	
389	08.99 1/	34.13	26.46		
483	06.74	34.10	26.77	2.17	
576	05.70	34.18	26.96	1.24	
760	04.82	34.42	27.26	1.43	
953	04.00	34.47	27.39	1.14	
1142	03.38	34.49	27.46	1.44	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D 1000 - \Delta D$ (dyn. m)
00	25.76	34.65	22.86	0.000	1.857
10	25.76	34.65	22.86	0.050	1.807
20	25.70	34.73	22.94	0.100	1.757
30	25.62	34.79	23.01	0.149	1.708
50	25.47	34.84	23.09	0.246	1.611
75	23.64	35.07	23.82	0.357	1.500
100	22.52	35.18	24.22	0.455	1.402
150	20.96	35.25	24.71	0.631	1.226
200	18.68	34.97	25.09	0.787	1.070
250	15.28	34.48	25.52	0.924	0.933
300	11.94	34.16	25.96	1.040	0.817
400	08.68	34.14	26.51	1.226	0.631
500	06.48	34.12	26.81	1.372	0.485
600	05.60	34.20	26.99	1.494	0.363
700	05.08	34.37	27.18	1.600	0.257
800	04.66	34.43	27.28	1.693	0.164
1000	03.87	34.48	27.40	1.857	0.000

1/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-salinity curve.

STATION 18

M/V Hugh M. Smith: Cruise 10, 22°08'N., 157°32'W., July 26, 1951. Messenger time: 1832 GCT. Weather: 01, cloud coverage 5. Wind: 070°, 22 kt. Sea: 3-5 ft. Wire angle: 35°. Depth of water: 2600 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
01	25.40	34.79	23.08	4.91	
10	25.41	34.78	23.07	4.90	
26	25.41	34.79	23.08	4.91	
51	25.39	34.80	23.09	4.90	
99	22.69	34.98	24.03	5.14	
190	20.41	35.21	24.83	4.86	
277	16.50	34.62	25.36	4.61	
359	10.66	34.14	26.19	4.67	
447	08.27 1/	34.09	26.54	2.72	
447	08.15 1/	34.09	26.56		
532	06.36	34.04	26.77	1.94	
707	04.88	34.29	27.15	1.46	
880	04.18	34.33	27.26	0.89	
1058	03.58	2/			

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	25.40	34.79	23.08	0.000	1.981
10	25.41	34.78	23.07	0.048	1.933
20	25.41	34.79	23.07	0.096	1.885
30	25.41	34.79	23.07	0.144	1.837
50	25.39	34.80	23.09	0.240	1.741
75	23.52	34.91	23.73	0.353	1.628
100	22.69	34.98	24.02	0.455	1.526
150	21.99	35.10	24.31	0.645	1.336
200	20.05	35.17	24.89	0.815	1.166
250	17.87	34.85	25.20	0.965	1.016
300	14.80	34.41	25.57	1.098	0.883
400	09.36	34.13	26.39	1.309	0.672
500	06.95	34.04	26.69	1.466	0.515
600	05.58	34.15	26.95	1.597	0.384
700	04.90	34.28	27.13	1.707	0.274
800	04.43	34.32	27.22	1.804	0.177
1000	03.78	34.37	27.32	1.981	0.000

1/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-salinity curve.

2/ Value did not fit the temperature-salinity curve.

STATION 19

M/V Hugh M. Smith: Cruise 10, 21°51'N., 156°45'W., July 27, 1951. Messenger time: 0308 GCT. Weather: 01, cloud coverage 8. Wind: 090°, 18 kt. Sea: 3-5 ft. Wire angle: 25°. Depth of water: 2750 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
01	25.60	34.66	23.00	4.90	
09	25.59	34.63	22.74	4.85	
27	25.54	34.60	22.70	4.87	
53	24.86	34.62	22.76	5.08	
106	22.68	35.09	23.32	5.14	
206	17.72	34.89	24.63	4.80	
304	11.76	34.10	25.96	3.60	
396	08.82	34.05	27.08	3.55	
496	06.68	34.04	27.56	2.23	
590	05.63	34.14	27.32	1.25	
786	04.35	34.34	27.45	1.34	
983	03.77	34.42	27.54	1.39	
1182	03.34	1/			

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	25.57	34.66	22.93	0.000	1.891
10	25.59	34.63	22.90	0.050	1.841
20	25.57	34.61	22.89	0.099	1.792
30	25.54	34.60	22.89	0.149	1.742
50	25.54	34.62	22.91	0.249	1.642
75	24.10	34.78	23.46	0.367	1.524
100	23.00	35.07	24.00	0.472	1.419
150	19.60	35.12	24.97	0.647	1.244
200	17.96	34.87	25.20	0.794	1.097
250	15.40	34.46	25.48	0.929	0.962
300	11.90	34.11	25.93	1.047	0.844
400	08.72	34.05	26.43	1.238	0.653
500	06.60	34.04	26.73	1.391	0.500
600	05.55	34.15	26.95	1.519	0.372
700	04.80	34.28	27.14	1.628	0.263
800	04.29	34.35	27.26	1.723	0.168
1000	03.72	34.43	27.38	1.891	0.000

1/ Value did not fit the temperature-salinity curve.

STATION 20

M/V Hugh M. Smith: Cruise 10, 21°10'N., 156°35'W., July 27, 1951. Messenger time: 0938 GCT. Weather: 01, cloud coverage not recorded. Wind: 060°, 3 kt. Sea: 1-3 ft. Wire angle: not recorded. Depth of water 256 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.20	34.78	23.14	4.87	
10	25.20	34.76	23.12	4.88	
24	25.20	34.77	23.13	4.88	
49	25.06	34.78	23.18	4.88	
99	23.28	35.03	23.90	5.12	
197	19.54	35.09	24.97	4.63	
295	11.10	34.11	26.08	4.30	
344	09.77	34.14	26.34	3.38	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	25.19	34.78			
10	25.20	34.76			
20	25.20	34.76			
30	25.19	34.77			
50	25.05	34.78			
75	24.22	34.86			
100	23.27	35.03			
150	21.38	35.20			
200	19.40	35.07			
250	14.55	34.37			
300	11.02	34.11			

STATION 21

M/V Hugh M. Smith: Cruise 10, 20°50'N., 156°45'W., July 27, 1951. Messenger time: 1340 GCT. Weather: 01, cloud coverage not recorded. Wind: 060°, 6 kt. Sea: < 1 ft. Wire angle: 00°. Depth of water: 27 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.80	34.59	22.82	4.80	
10	25.65	34.57	22.84	4.82	
25	25.66	34.57	22.84	4.80	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	25.77	34.59			
10	25.65	34.57			
20	25.65	34.57			

STATION 22

M/V Hugh M. Smith: Cruise 10, 20°20'N., 156°39'W., July 27, 1951. Messenger time: 1837 GCT. Weather: 01, cloud coverage 2. Wind: 060°, 24 kt. Sea: 3-5 ft. Wire angle: 38°. Depth of water: 1200 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
01	25.80	34.64	22.84	4.93	
08	25.86	34.63	22.82	4.86	
22	25.87	1/		4.88	
45	25.86	34.61	22.81	4.84	
86	25.00	34.68	23.12	4.92	
162	19.99	34.98	24.77	4.72	
240	16.16	34.65	25.46	4.31	
318	11.15	34.20	26.14	3.54	
400	08.58	34.20	26.58	2.28	
481	06.86	34.22	26.85	1.33	
654	05.56	34.45	27.20	1.65	
833	04.77	34.45	27.29	1.02	
1021	03.74	2/			

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	25.83	34.64	22.83	0.000	1.882
10	25.86	34.63	22.81	0.050	1.832
20	25.87	34.62	22.80	0.101	1.781
30	25.87	34.61	22.80	0.152	1.730
50	25.86	34.61	22.80	0.253	1.629
75	25.70	34.61	22.85	0.380	1.502
100	23.60	34.88	23.68	0.496	1.386
150	20.43	34.99	24.65	0.686	1.196
200	17.50	34.79	25.25	0.839	1.043
250	14.50	34.45	25.67	0.969	0.913
300	11.95	34.22	26.01	1.081	0.801
400	08.58	34.20	26.57	1.262	0.620
500	06.67	34.23	26.87	1.401	0.481
600	05.89	34.34	27.06	1.518	0.364
700	05.37	34.41	27.18	1.621	0.261
800	04.92	34.44	27.26	1.715	0.167
1000	03.85	34.48	27.41	1.882	0.000

1/ Sample lost.

2/ Value did not fit the temperature-salinity curve.

STATION 23

M/V Hugh M. Smith: Cruise 10, 19°37'N., 156°40'W., July 27, 1951. Messenger time: 0017 GCT. Weather: 01, cloud coverage 1. Wind: 180°, 10 kt. Sea: <1 ft. Wire angle: 35°. Depth of water: 2550 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.40	34.62	22.65	4.84	
09	25.82	34.66	22.86	4.86	
25	25.52	34.66	22.95	4.87	
50	23.82	34.69	23.48	4.98	
96	22.27	35.08	24.22	5.04	
180	16.92	34.83	25.42	4.93	
255	12.48	34.33	26.00	3.77	
329	09.58 1/	34.18	26.40	2.96	
329	09.64 1/	34.18	26.39		
406	07.85	34.17	26.66	2.07	
490	06.98	34.24	26.85	1.17	
632	05.85	34.40	27.12	1.13	
789	05.18	34.44	27.23	1.00	
964	04.32	34.44	27.33	1.17	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	26.38	34.62	22.64	0.000	1.753
10	25.81	34.66	22.85	0.051	1.702
20	25.60	34.66	22.92	0.101	1.652
30	25.27	34.66	23.02	0.150	1.603
50	23.82	34.69	23.48	0.243	1.510
75	23.04	34.93	23.88	0.349	1.404
100	22.17	35.08	24.25	0.446	1.307
150	18.96	35.02	25.06	0.613	1.140
200	15.28	34.64	25.65	0.747	1.006
250	12.70	34.35	25.96	0.860	0.893
300	10.65	34.21	26.24	0.959	0.794
400	07.92	34.17	26.65	1.125	0.628
500	06.90	34.26	26.87	1.261	0.492
600	06.08	34.38	27.07	1.378	0.375
700	05.53	34.42	27.17	1.481	0.272
800	05.11	34.44	27.24	1.577	0.176
1000	04.13	34.44	27.34	1.753	0.000

1/ Thermometers did not agree within 0.02 °C tolerance. Average value used in constructing temperature-salinity curve.

STATION 24

M/V Hugh M. Smith: Cruise 10, 19°02'N., 156°40'W., July 28, 1951. Messenger time: 0542 GCT. Weather: 01, cloud coverage 6. Wind: 120°, 18 kt. Sea: 3-5 ft. Wire angle: 15°. Depth of water: 2530 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
01	26.40	34.63	22.64	4.85	
11	26.44	34.64	22.64	4.88	
31	26.40	34.62	22.64	4.88	
60	25.94	34.60	22.77	4.90	
118	24.08	34.72	23.43	4.92	
232	16.24	34.60	25.40	4.20	
345	09.34	34.17	26.43	3.09	
454	07.56	34.23	26.75	1.39	
569	06.72	34.34	26.96	0.80	
680	05.66	34.41	27.15	0.86	
907	04.72	34.49	27.32	1.36	
1127	03.98	34.51	27.42	1.18	
1340	03.40	34.54	27.50	1.47	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	26.43	34.63	22.64	0.000	1.936
10	26.44	34.64	22.64	0.052	1.884
20	26.42	34.63	22.64	0.104	1.832
30	26.40	34.62	22.64	0.157	1.779
50	26.22	34.60	22.68	0.261	1.675
75	25.66	34.61	22.86	0.389	1.547
100	24.98	34.64	23.09	0.512	1.424
150	21.48	35.01	24.38	0.722	1.214
200	18.40	34.86	25.08	0.886	1.050
250	14.80	34.45	25.61	1.022	0.914
300	11.40	34.22	26.11	1.132	0.804
400	08.15	34.20	26.64	1.305	0.631
500	07.05	34.29	26.87	1.442	0.494
600	06.49	34.36	27.00	1.562	0.374
700	05.54	34.42	27.17	1.669	0.267
800	05.05	34.46	27.26	1.764	0.172
1000	04.40	34.50	27.36	1.936	0.000

STATION 25

M/V Hugh M. Smith: Cruise 10, 18°22'N., 156°40'W., July 28, 1951. Messenger time: 1205 GCT. Weather: 02, cloud coverage not recorded. Wind: 040°, 21 kt. Sea: 5-8 ft. Wire angle: 25°. Depth of water: 2600 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.80	34.67	22.86	4.88	
07	25.84	34.65	22.84	4.85	
21	25.86	34.67	22.85	4.86	
42	25.84	34.69	22.87	4.84	
80	25.50	34.68	22.97	4.90	
150	22.04	34.91	24.16	5.05	
218	18.12	34.82	25.12	4.51	
278	12.84	34.28	25.89	3.84	
338	09.51	34.18	26.41	3.05	
395	07.94	34.19	26.67	2.00	
511	06.38	34.42	27.06	1.54	
645	05.60	34.39	27.14	0.87	
811	04.86	34.44	27.27	1.00	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	25.84	34.67	22.85	0.000	1.913
10	25.85	34.65	22.83	0.050	1.863
20	25.86	34.67	22.84	0.101	1.812
30	25.85	34.68	22.86	0.151	1.762
50	25.84	34.69	22.87	0.251	1.662
75	25.50	34.68	22.96	0.376	1.537
100	25.32	34.68	23.02	0.498	1.415
150	22.04	34.91	24.15	0.716	1.197
200	19.38	34.91	24.87	0.891	1.022
250	15.45	34.50	25.50	1.034	0.879
300	11.55	34.22	26.08	1.148	0.765
400	07.84	34.19	26.68	1.319	0.594
500	06.48	34.41	27.04	1.446	0.467
600	05.78	34.41	27.13	1.552	0.361
700	05.33	34.40	27.18	1.651	0.262
800	04.90	34.44	27.26	1.745	0.168
1000	04.10	34.50	27.40	1.913	0.000

STATION 26

M/V Hugh M. Smith: Cruise 10, 18°10'N., 155°35'W., July 29, 1951. Messenger time: 0845 GCT. Weather: 01, cloud coverage not recorded. Wind: 080°, 20 kt. Sea: 3-5 ft. Wire angle: 17°. Depth of water: 2675 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.20	34.60	23.00	4.88	
10	25.22	34.69	23.06	4.88	
29	25.22	34.61	23.00	4.88	
56	25.01	34.63	23.08	4.93	
112	22.14	35.04	24.23	5.10	
218	14.04	34.35	25.69	3.61	
323	09.03	34.19	26.50	2.82	
424	07.31	34.22	26.78	1.33	
529	06.52	34.36	27.00	1.08	
631	05.78	34.40	27.13	0.71	
840	04.74	34.49	27.32	1.08	
1043	04.02	34.52	27.42	1.15	
1246	03.54	34.54	27.49	1.25	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	25.20	34.60	22.99	0.000	1.744
10	25.22	34.69	23.06	0.048	1.696
20	25.22	34.66	23.03	0.097	1.647
30	25.22	34.61	23.00	0.145	1.599
50	25.12	34.62	23.03	0.243	1.501
75	23.52	34.87	23.70	0.356	1.388
100	22.60	35.00	24.06	0.458	1.286
150	20.40	35.06	24.72	0.637	1.107
200	16.67	34.68	25.36	0.787	0.957
250	11.30	34.21	26.12	0.902	0.842
300	09.57	34.19	26.41	0.993	0.751
400	07.62	34.21	26.73	1.147	0.597
500	06.73	34.33	26.94	1.276	0.468
600	06.00	34.39	27.09	1.388	0.356
700	05.38	34.44	27.20	1.489	0.255
800	04.89	34.49	27.30	1.580	0.164
1000	04.15	34.52	27.41	1.744	0.000

STATION 27

M/V Hugh M. Smith: Cruise 10, 18°37'N., 154°27'W., July 29, 1951. Messenger time: 1820 GCT. Weather: 01, cloud coverage 5. Wind: 070°, 14 kt. Sea: 1-3 ft. Wire angle: 35°. Depth of water: 2900 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.20	34.61	23.00	4.86	
09	25.23	34.56	22.96	4.85	
26	25.24	34.56	22.96	4.85	
51	24.56	34.55	23.16	4.97	
97	22.50	35.00	24.10	5.09	
188	16.54	34.76	25.46	4.63	
276	10.34	34.16	26.26	3.12	
359	1/	2/		1.31	
444	07.42	34.34	26.86	0.74	
527	06.87	34.38	26.97	0.42	
701	05.46	34.44	27.20	0.92	
884	04.82	34.47	27.30	0.64	
1075	04.14	34.41	27.33	0.68	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	25.21	34.61	23.00	0.000	1.741
10	25.23	34.56	22.96	0.049	1.692
20	25.24	34.56	22.95	0.098	1.643
30	25.24	34.56	22.95	0.147	1.594
50	24.57	34.55	23.15	0.244	1.497
75	23.22	34.88	23.79	0.355	1.386
100	22.42	35.01	24.12	0.455	1.286
150	19.65	35.04	24.90	0.629	1.112
200	15.35	34.61	25.61	0.767	0.974
250	11.20	34.18	26.12	0.877	0.864
300	09.80	34.18	26.36	0.970	0.771
400	07.98	34.30	26.74	1.125	0.616
500	07.05	34.36	26.92	1.254	0.487
600	06.26	34.41	27.07	1.369	0.372
700	05.47	34.44	27.19	1.471	0.270
800	05.10	34.46	27.25	1.565	0.176
1000	04.40	34.46	27.33	1.741	0.000

1/ Values did not fit the temperature-depth curve.

2/ Value did not fit the temperature-salinity curve.

STATION 28

M/V Hugh M. Smith: Cruise 10, 19°13'N., 154°30'W., July 29, 1951. Messenger time: 2330 GCT. Weather: 01, cloud coverage 5. Wind: 050°, 18 kt. Sea: 3-5 ft. Wire angle: 27°. Depth of water: 3000 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.30	34.60	22.97	4.89	
09	25.26	34.60	22.98	4.92	
27	25.16	34.60	23.01	4.93	
53	25.13	34.59	23.01	4.90	
104	22.68	35.10	24.12	5.19	
204	17.54	34.78	25.23	4.50	
303	10.28	34.16	26.27	3.56	
398	08.95 1/	2/		0.80	
398	09.01 1/				
497	07.65	34.35	26.84	0.54	
593	06.62	34.38	27.00	0.44	
795	05.32	34.47	27.24	0.91	
997	04.30	34.46	27.35	0.90	
1202	03.76	34.49	27.43	2.38	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	25.28	34.60	22.97	0.000	1.849
10	25.25	34.60	22.98	0.049	1.800
20	25.20	34.60	22.99	0.098	1.751
30	25.16	34.60	23.01	0.147	1.702
50	25.13	34.59	23.01	0.244	1.605
75	24.05	34.73	23.44	0.361	1.488
100	22.82	35.07	24.05	0.466	1.383
150	20.52	35.10	24.71	0.646	1.203
200	17.72	34.82	25.22	0.798	1.051
250	13.50	34.30	25.76	0.926	0.923
300	10.38	34.16	26.25	1.030	0.819
400	08.95	34.22	26.53	1.201	0.648
500	07.62	34.36	26.84	1.345	0.504
600	06.55	34.38	27.01	1.467	0.382
700	05.87	34.42	27.13	1.575	0.274
800	05.30	34.48	27.24	1.673	0.176
1000	04.25	34.46	27.35	1.849	0.000

1/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-depth curve.

2/ Value did not fit the temperature-salinity curve.

STATION 29

M/V Hugh M. Smith: Cruise 10, 19°55'N., 154°29'W., July 30, 1951. Messenger time: 0530 GCT. Weather: 01, cloud coverage 9. Wind: 020°, 13 kt. Sea: 1-3 ft. Wire angle: 25°. Depth of water: no data.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.30	34.63	22.98	4.85	
10	25.34	34.65	22.99	4.89	
27	25.30	34.65	23.01	4.88	
54	24.44	34.54	23.18	5.08	
106	22.45	34.98	24.10	5.04	
210	17.92	34.77	25.14	4.46	
311	10.41	34.22	26.29	2.81	
408	09.19 1/	2/		1.05	
408	09.04 1/				
510	07.21	34.30	26.86	0.83	
609	06.48	34.39	27.03	0.62	
816	05.08	34.46	27.26	1.08	
1023	04.33	34.49	27.37	0.91	
1231	03.70	2/			

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	25.33	34.63	22.98	0.000	1.871
10	25.34	34.65	22.99	0.049	1.822
20	25.31	34.65	23.00	0.098	1.773
30	25.29	34.65	23.01	0.146	1.725
50	25.12	34.54	22.97	0.244	1.627
75	23.19	34.79	23.74	0.358	1.513
100	22.55	34.96	24.05	0.460	1.411
150	21.25	35.08	24.50	0.644	1.227
200	18.75	34.86	24.99	0.808	1.063
250	13.70	34.34	25.75	0.941	0.930
300	10.67	34.22	26.24	1.045	0.826
400	09.22	34.24	26.50	1.218	0.653
500	07.33	34.29	26.83	1.364	0.507
600	06.51	34.38	27.01	1.486	0.385
700	05.79	34.43	27.15	1.593	0.278
800	05.16	34.46	27.25	1.690	0.181
1000	04.86	34.49	27.30	1.871	0.000

1/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-depth curve.

2/ Value did not fit the temperature-salinity curve.

STATION 30

M/V Hugh M. Smith: Cruise 10, 20°30'N., 154°30'W., July 30, 1951. Messenger time: 1115 GCT. Weather: 02, cloud coverage not recorded. Wind: 080°, 22 kt. Sea: 3-5 ft. Wire angle: 25°. Depth of water: 3000 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.30	34.63	22.99	4.89	
09	25.33	34.61	22.97	4.88	
27	25.32	34.62	22.98	4.89	
53	25.25	34.59	22.98	4.91	
106	22.57	34.94	24.03	5.16	
208	18.38	34.88	25.10	4.55	
309	11.06	34.19	26.15	3.09	
407	09.00 1/	2/		1.22	
407	09.06 1/				
510	06.90	34.23	26.85	1.16	
608	06.13	34.33	27.03	0.72	
816	05.04	34.50	27.30	1.21	
1023	04.33	34.51	27.38	1.03	
1229	03.69	2/		3/	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	25.32	34.63	22.98	0.000	1.893
10	25.33	34.61	22.96	0.049	1.844
20	25.32	34.62	22.97	0.098	1.795
30	25.31	34.62	22.98	0.147	1.746
50	25.28	34.59	22.96	0.245	1.648
75	23.75	34.66	23.47	0.362	1.531
100	22.73	34.91	23.96	0.468	1.425
150	21.50	35.12	24.46	0.656	1.237
200	19.00	34.94	24.99	0.820	1.073
250	15.10	34.49	25.57	0.958	0.935
300	11.48	34.20	26.08	1.071	0.822
400	09.14	34.19	26.48	1.253	0.640
500	07.05	34.22	26.81	1.400	0.493
600	06.19	34.32	27.01	1.523	0.370
700	05.60	34.44	27.18	1.629	0.264
800	05.10	34.49	27.28	1.723	0.170
1000	04.39	34.51	27.37	1.893	0.000

1/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-depth curve.

2/ Value did not fit the temperature-salinity curve.

3/ Value did not fit the temperature-oxygen curve.

STATION 31

M/V Hugh M. Smith: Cruise 10, 21°06'N., 154°54'W., July 30, 1951. Messenger time: 1700 GCT. Weather: 01, cloud coverage 5. Wind: 070°, 18 kt. Sea: 1-3 ft. Wire angle: 10°. Depth of water: no data.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.60	34.95	23.13	4.78	
10	25.64	34.96	23.14	4.82	
31	25.68	34.96	23.12	4.82	
61	23.60	34.97	23.76	5.21	
120	20.94	35.27	24.73	4.94	
235	14.92	34.50	25.62	4.62	
349	09.52	34.14	26.38	3.12	
457	06.92	34.05	26.71	2.06	
569	05.44	34.14	26.98	1.10	
679	04.84	34.23	27.11	0.64	
900	04.20	34.50	27.39	1.46	
1117	03.62	34.50	27.45	1.40	
1330	03.16	34.55	27.53	1.60	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	25.64	34.95	23.12	0.000	1.805
10	25.64	34.96	23.13	0.047	1.758
20	25.66	34.96	23.13	0.095	1.710
30	25.68	34.96	23.12	0.143	1.662
50	25.63	34.96	23.13	0.238	1.567
75	23.25	35.05	23.91	0.348	1.457
100	21.93	35.24	24.43	0.442	1.363
150	19.97	35.18	24.92	0.608	1.197
200	17.38	34.83	25.31	0.754	1.051
250	13.92	34.39	25.75	0.880	0.925
300	11.38	34.21	26.11	0.987	0.818
400	08.20	34.08	26.54	1.165	0.640
500	06.23	34.07	26.81	1.309	0.496
600	05.22	34.16	27.00	1.431	0.374
700	04.78	34.25	27.12	1.539	0.266
800	04.48	34.34	27.23	1.636	0.169
1000	03.95	34.50	27.41	1.805	0.000

STATION 32

M/V Hugh M. Smith: Cruise 10, 21°25'N., 155°30'W., July 30, 1951. Messenger time: 2107 GCT. Weather: 02, cloud coverage 8. Wind: 100°, 21 kt. Sea: 3-5 ft. Wire angle: 16°. Depth of water: no data.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.50	34.68	22.96	4.90	
10	25.53	34.65	22.94	4.92	
30	25.46	34.64	22.95	4.90	
59	24.92	34.64	23.12	5.07	
116	21.66	34.96	24.30	5.01	
233	12.44	34.24	25.94	4.26	
346	09.04	34.23	26.53	2.39	
455	06.36	34.08	26.80	1.89	
568	05.42	34.22	27.03	0.70	
678	05.00	34.38	27.21	0.85	
903	04.38	34.49	27.36	1.04	
1122	03.74	34.52	27.45	1.33	
1337	03.27	34.52	27.50	1.44	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	25.53	34.68	22.95	0.000	1.757
10	25.53	34.65	22.93	0.049	1.708
20	25.50	34.64	22.93	0.099	1.658
30	25.46	34.64	22.95	0.148	1.609
50	25.43	34.64	22.95	0.247	1.510
75	24.23	34.69	23.35	0.365	1.392
100	22.75	34.84	23.90	0.473	1.284
150	19.43	34.94	24.88	0.652	1.105
200	14.50	34.40	25.63	0.791	0.966
250	11.83	34.23	26.04	0.902	0.855
300	10.40	34.24	26.31	0.998	0.759
400	07.47	34.12	26.68	1.159	0.598
500	05.88	34.12	26.89	1.292	0.465
600	05.26	34.29	27.10	1.405	0.352
700	04.95	34.40	27.22	1.504	0.253
800	04.67	34.45	27.29	1.594	0.163
1000	04.09	34.52	27.41	1.757	0.000

STATION 33

M/V Hugh M. Smith: Cruise 10, 21°51'N., 156°45'W., July 31, 1951. Messenger time: 0901 GCT. Weather: 01, cloud coverage not recorded. Wind: 060°, 21 kt. Sea: 1-3 ft. Wire angle: 20°. Depth of water: 2700 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
01	25.50	34.73	23.01	4.88	
10	25.49	34.71	22.99	4.90	
28	25.49	34.70	22.98	4.89	
56	25.40	34.69	23.01	4.94	
112	22.36	35.15	24.25	5.17	
221	15.90	1/		4.18	
330	11.16	34.23	26.17	4.91	
434	08.28	34.13	26.57	2.66	
543	06.15	34.09	26.84	1.66	
647	05.18	34.20	27.04	0.95	
864	04.26	34.44	27.34	1.44	
1077	03.64	34.49	27.44	1.27	
1287	03.16	34.51	27.50	1.65	

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	25.48	34.73	23.01	0.000	1.859
10	25.49	34.71	22.99	0.049	1.810
20	25.49	34.70	22.98	0.098	1.761
30	25.48	34.70	22.98	0.147	1.712
50	25.43	34.69	22.99	0.245	1.614
75	23.75	34.84	23.61	0.360	1.499
100	22.65	35.08	24.11	0.462	1.397
150	20.15	35.18	24.87	0.636	1.223
200	17.07	34.77	25.33	0.782	1.077
250	14.52	34.46	25.67	0.910	0.949
300	12.42	34.28	25.96	1.023	0.836
400	09.12	34.17	26.46	1.211	0.648
500	06.90	34.09	26.73	1.363	0.496
600	05.55	34.14	26.95	1.491	0.368
700	04.86	34.29	27.15	1.601	0.258
800	04.45	34.40	27.28	1.695	0.164
1000	03.89	34.48	27.40	1.859	0.000

1/ No sample.

STATION 1

M/V Hugh M. Smith: Cruise 12, 20°18'N., 159°18'W., October 24, 1951. Messenger time: 1320 GCT. Weather: 00, cloud coverage 3. Wind: 120°, 9 kt. Sea: 3-5 ft. Wire angle: 18°. Depth of water: 2500 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.20	34.96	22.98		0.32
10	26.17	34.97	22.98		0.41
29	26.20	34.96	22.96		0.18
59	24.84	34.90	23.33		0.31
115	21.34	35.01	24.43		0.42
230	13.49	34.34	25.80		1.28
341	09.20	34.16	26.45		1.99
446	07.18	34.22	26.80		2.73
555	06.06	34.29	27.01		3.07
662	05.38	34.38	27.16		3.20
881	04.54	34.43	27.30		3.22
1093	03.82	34.43	27.37		2.91
1305	03.29	34.38	27.38		2.60

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	26.15	34.96	22.97	0.000	1.777
10	26.17	34.97	22.97	0.049	1.728
20	26.19	34.97	22.97	0.098	1.679
30	26.20	34.96	22.96	0.147	1.630
50	26.18	34.92	22.93	0.246	1.531
75	23.38	34.98	23.82	0.359	1.418
100	21.95	35.00	24.25	0.457	1.320
150	19.88	34.95	24.77	0.631	1.146
200	16.25	34.62	25.41	0.777	1.000
250	12.60	34.28	25.93	0.897	0.880
300	10.60	34.18	26.22	0.997	0.780
400	07.92	34.18	26.66	1.163	0.614
500	06.52	34.26	26.92	1.296	0.481
600	05.71	34.32	27.07	1.410	0.367
700	05.18	34.40	27.20	1.512	0.265
800	04.78	34.43	27.27	1.605	0.172
1000	04.15	34.44	27.34	1.777	0.000

STATION 2

M/V Hugh M. Smith: Cruise 12, 21°01'N, 159°14'W., October 24, 1951. Messenger time: 2115 GCT. Weather: 00, cloud coverage 7. Wind: 120°, 9 kt. Sea: 1-3 ft. Wire angle: 24°. Depth of water: 2500 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.50	34.88	22.81		0.32
10	26.44	34.89	22.83		0.37
28	26.43	34.88	22.83		0.32
55	26.42	34.88	22.83		0.27
109	22.22	34.98	24.16		0.35
214	16.68	34.67	25.35		0.82
317	10.25	34.14	26.26		1.76
414	07.78	34.13	26.64		2.43
518	06.62	34.31	26.95		2.96
617	05.71	34.30	27.06		3.10
617					3.21 1/
825	04.82	34.42	27.27		3.17
1032	04.04	34.50	27.41		3.05
1032					3.16 1/
1239	03.48				

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	26.48	34.88	22.81	0.000	1.851
10	26.44	34.89	22.83	0.050	1.801
20	26.43	34.89	22.83	0.101	1.750
30	26.43	34.88	22.82	0.151	1.700
50	26.43	34.88	22.82	0.252	1.599
75	25.25	34.90	23.21	0.374	1.477
100	22.72	34.98	24.01	0.482	1.369
150	20.61	34.97	24.59	0.666	1.185
200	17.62	34.75	25.19	0.822	1.029
250	13.10	34.32	25.86	0.949	0.902
300	10.87	34.17	26.17	1.052	0.799
400	08.01	34.11	26.59	1.224	0.627
500	06.77	34.31	26.92	1.360	0.491
600	05.83	34.30	27.04	1.476	0.375
700	05.31	34.35	27.14	1.581	0.270
800	04.92	34.41	27.23	1.678	0.173
1000	04.15	34.49	27.38	1.851	0.000

1/ Values do not agree within 0.02 µg at/l tolerance. Average value used in constructing phosphate-temperature curve.

STATION 3

M/V Hugh M. Smith: Cruise 12, 21°46'N., 159°12'W., October 25, 1951. Messenger time: 0443 GCT. Weather: 02, cloud coverage 7. Wind: 320°, 8 kt. Sea: 3-5 ft. Wire angle: 05°. Depth of water: 1850 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.80	34.88	22.70		0.27
10	26.64	34.87	22.75		0.28
31	26.60	34.87	22.77		0.29
31					0.23 1/
60	26.58	34.87	22.77		0.30
118	21.85	35.12	24.37		0.33
234	15.42	34.52	25.53		0.96
234					0.91 1/
346	09.21	34.13	26.42		1.96
455	07.06	34.10	26.72		2.54
568	05.92	34.21	26.96		2.98
677	04.94	34.29	27.14		3.22
900	04.50	34.46	27.32		3.18
1114	03.84	34.50	27.43		3.20
1324	03.31	34.50	27.48		3.02

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	26.83	34.88	22.70	0.000	1.871
10	26.64	34.87	22.75	0.051	1.820
20	26.62	34.87	22.76	0.102	1.769
30	26.60	34.87	22.76	0.154	1.717
50	26.59	34.87	22.77	0.256	1.615
75	25.85	34.89	23.01	0.381	1.490
100	23.25	35.07	23.93	0.492	1.379
150	20.28	35.02	24.72	0.675	1.196
200	18.10	34.82	25.12	0.830	1.041
250	14.20	34.42	25.71	0.961	0.910
300	10.95	34.20	26.18	1.068	0.803
400	07.97	34.10	26.59	1.239	0.632
500	06.58	34.14	26.81	1.381	0.490
600	05.59	34.22	27.00	1.503	0.368
700	04.87	34.32	27.17	1.608	0.263
800	04.68	34.42	27.27	1.702	0.169
1000	04.19	34.49	27.38	1.871	0.000

1/ Values do not agree within 0.02 µg at/l tolerance. Average value used in constructing phosphate-temperature curve.

STATION 4

M/V Hugh M. Smith: Cruise 12, 22°28'N., 159°14'W., October 25, 1951. Messenger time: 1133 GCT. Weather: 00, cloud coverage 3. Wind: 060°, 6 kt. Sea: 1-3 ft. Wire angle: 12°. Depth of water: 1830 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.20	34.93	22.92		0.33
00					0.26 1/
10	26.26	34.91	22.91		0.31
10					0.24 1/
29	26.29	34.92	22.90		0.38
29					0.28 1/
58	26.08	34.93	22.97		0.25
118	21.45	35.04	24.42		0.40
231	14.90	34.42	25.57		1.07
344	09.44	34.12	26.38		1.51
453	07.02	34.04	26.68		2.25
565	05.59	34.11	26.92		2.97
673	05.58	34.34	27.10		3.16
896	04.44	34.43	27.31		3.18
1110	03.82	34.51	27.44		3.07
1318	03.28	34.47	27.46		2.11

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	26.25	34.93	22.92	0.000	1.852
10	26.26	34.91	22.90	0.050	1.802
20	26.28	34.91	22.89	0.099	1.753
30	26.29	34.92	22.90	0.149	1.703
50	26.28	34.93	22.91	0.249	1.603
75	24.45	34.95	23.49	0.366	1.486
100	22.17	35.03	24.21	0.469	1.383
150	19.75	34.94	24.80	0.643	1.209
200	16.25	34.55	25.36	0.790	1.062
250	14.02	34.35	25.69	0.916	0.936
300	11.46	34.21	26.09	1.025	0.827
400	07.96	34.06	26.56	1.202	0.650
500	06.35	34.05	26.77	1.347	0.505
600	05.58	34.20	26.99	1.472	0.380
700	05.48	34.35	27.12	1.580	0.272
800	04.91	34.39	27.22	1.679	0.173
1000	04.12	34.49	27.39	1.852	0.000

1/ Values do not agree within 0.02 µg at/l tolerance. Average value used in constructing phosphate-temperature curve.

STATION 5

M/V Hugh M. Smith: Cruise 12, 23°02'N., 159°15'W., October 25, 1951. Messenger time: 1740 GCT. Weather: 00, cloud coverage 3. Wind: 170°, 8 kt. Sea: 1-3 ft. Wire angle: 12°. Depth of water: 2600 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.20	34.97	22.96		0.25
10	26.22	34.97	22.96		0.26
25	26.22	34.95	22.95		0.25
54	26.23	34.92	22.92		0.80
105	22.07	35.14	24.33		0.94
207	17.23	34.79	25.32		1.08
307	12.12	34.28	26.03		1.13
412	08.14 1/	34.04	26.52		1.88
412	08.21 1/	34.04	26.51		
514	07.02	34.22	26.82		2.96
615	05.98	34.28	27.01		3.17
812	05.04	34.41	27.23		3.30
1013	04.20	34.46	27.36		3.18
1207	03.63	34.47	27.42		2.11

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	26.22	34.97	22.96	0.000	1.862
10	26.22	34.97	22.96	0.049	1.813
20	26.22	34.96	22.95	0.098	1.764
30	26.22	34.94	22.94	0.148	1.714
50	26.23	34.92	22.92	0.247	1.615
75	23.90	35.08	23.75	0.361	1.501
100	22.25	35.14	24.27	0.460	1.402
150	19.72	35.04	24.88	0.630	1.232
200	17.62	34.84	25.26	0.778	1.084
250	14.42	34.48	25.71	0.907	0.955
300	12.35	34.30	25.99	1.018	0.844
400	08.42	34.05	26.48	1.204	0.658
500	07.17	34.21	26.79	1.352	0.510
600	06.12	34.26	26.97	1.477	0.385
700	05.47	34.38	27.15	1.586	0.276
800	05.09	34.41	27.21	1.684	0.178
1000	04.22	34.46	27.35	1.862	0.000

1/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-depth curve.

STATION 6

M/V Hugh M. Smith: Cruise 12, 22°46'N., 158°25'W., October 26, 1951. Messenger time: 0115 GCT. Weather: 00, cloud coverage 4. Wind: 160°, 11 kt. Sea: 1-3 ft. Wire angle: 18°. Depth of water: 2600 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.30	34.79	22.79		0.19
10	26.21	34.85	22.87		0.19
10					0.29 1/
29	26.24	34.85	22.87		0.27
29					0.20 1/
57	25.92	34.85	22.97		0.23
114	22.94	35.06	24.02		0.25
224	16.20	34.55	25.37		0.74
333	10.18	34.16	26.28		1.55
437	07.55	33.99	26.57		1.95
545	05.76	34.04	26.84		2.72
649	04.92	34.17	27.05		3.06
865	04.20	34.39	27.30		3.09
1074	03.76	34.48	27.42		2.98
1282	03.22	34.49	27.48		1.53

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	26.34	34.79	22.79	0.000	1.915
10	26.31	34.85	22.84	0.051	1.864
20	26.27	34.85	22.85	0.101	1.814
30	26.23	34.85	22.86	0.151	1.764
50	25.95	34.85	22.95	0.250	1.665
75	25.88	34.85	22.97	0.374	1.541
100	23.98	34.99	23.66	0.489	1.426
150	20.80	35.04	24.59	0.681	1.234
200	18.07	34.74	25.07	0.840	1.075
250	14.65	34.45	25.64	0.975	0.940
300	11.55	34.25	26.11	1.085	0.830
400	08.38	34.04	26.48	1.265	0.650
500	06.38	33.99	26.72	1.416	0.499
600	05.25	34.10	26.95	1.545	0.370
700	04.64	34.25	27.14	1.654	0.261
800	04.31	34.36	27.26	1.748	0.167
1000	03.90	34.47	27.39	1.915	0.000

1/ Values do not agree within 0.02 µg at/l tolerance. Average value used in constructing phosphate-temperature curve.

STATION 7

M/V Hugh M. Smith: Cruise 12, 22°09'N., 158°24'W., October 26, 1951. Messenger time: 0805 GCT. Weather: 00, cloud coverage 6. Wind: 060°, 19 kt. Sea: 5-8 ft. Wire angle: 10°. Depth of water: 2700 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.50	34.86	22.81		0.27
10	26.46	34.84	22.79		0.30
29	26.24	34.91	22.91		0.24
60	26.14	34.89	22.93		0.36
118	22.62	35.03	24.09		0.51
232	15.59	34.52	25.49		0.94
346	09.36	34.10	26.37		1.87
454	07.35	34.10	26.69		2.58
568	06.03	34.23	26.96		3.02
678	05.30	34.36	27.15		3.27
902	04.44	34.44	27.32		3.28
1117	03.84	34.50	27.43		3.15
1325	03.30	34.49	27.47		2.58

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	26.46	34.86	22.80	0.000	1.881
10	26.46	34.84	22.79	0.051	1.830
20	26.41	34.89	22.84	0.101	1.780
30	26.23	34.91	22.91	0.151	1.730
50	26.16	34.89	22.92	0.251	1.630
75	25.10	34.88	23.24	0.371	1.510
100	23.40	34.99	23.83	0.481	1.400
150	20.73	35.02	24.60	0.669	1.212
200	18.00	34.76	25.10	0.827	1.054
250	14.11	34.39	25.71	0.959	0.922
300	11.10	34.19	26.14	1.067	0.814
400	08.23	34.07	26.53	1.243	0.638
500	06.73	34.15	26.80	1.389	0.492
600	05.78	34.27	27.02	1.511	0.370
700	05.20	34.38	27.18	1.615	0.266
800	04.77	34.41	27.25	1.709	0.172
1000	04.15	34.48	27.37	1.881	0.000

STATION 8

M/V Hugh M. Smith: Cruise 12, 21°30'N., 158°26'W., October 26, 1951. Messenger time: 1439 GCT. Weather: 00, cloud coverage 5. Wind: 110°, 10 kt. Sea: 3-5 ft. Wire angle: 00°. Depth of water: 1350 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.50	34.88	22.80		0.29
00					0.42 1/
10	26.50	34.96	22.87		0.31
10					0.40 1/
26	26.38	34.86	22.83		0.36
26					0.41 1/
55	26.16	34.88	22.91		0.45
55					0.35 1/
110	24.34	34.86	23.45		0.40
218	17.56	34.79	25.24		0.78
326	10.53	34.20	26.26		1.84
326					1.94 1/
438	07.58	34.14	26.69		2.73
546	06.23	34.21	26.92		3.01
546					3.14 1/
653	05.42	34.29	27.09		3.26
862	04.67	34.44	27.29		3.33
862					3.36 1/
1073	04.10	34.48	27.39		3.23
1269	03.53	34.50	27.45		2.75

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	26.52	34.88	22.80	0.000	1.943
10	26.50	34.96	22.86	0.050	1.893
20	26.43	34.88	22.82	0.101	1.842
30	26.35	34.86	22.83	0.151	1.792
50	26.19	34.88	22.90	0.251	1.692
75	26.00	34.88	22.96	0.375	1.568
100	25.10	34.84	23.21	0.496	1.447
150	21.95	35.03	24.27	0.707	1.236
200	18.50	34.88	25.07	0.873	1.070
250	15.88	34.62	25.50	1.012	0.931
300	12.00	34.29	26.05	1.127	0.816
400	08.27	34.13	26.57	1.305	0.638
500	06.73	34.20	26.84	1.447	0.496
600	05.77	34.23	26.99	1.568	0.375
700	05.19	34.36	27.16	1.675	0.268
800	04.82	34.42	27.25	1.770	0.173
1000	04.29	34.47	27.35	1.943	0.000

1/ Values do not agree within 0.02 µg at/l tolerance. Average value used in constructing phosphate-temperature curve.

STATION 9

M/V Hugh M. Smith: Cruise 12, 20°46'N., 158°28'W., October 26, 1951. Messenger time: 2123 GCT. Weather: 01, cloud coverage 6. Wind: 140°, 11 kt. Sea: 1-3 ft. Wire angle: 30°. Depth of water: 2400 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.70	34.88	22.75		0.28
09	26.61	34.88	22.77		0.30
27	26.57	34.87	22.78		0.33
52	26.40	34.87	22.83		0.26
100	23.60	34.92	23.72		0.39
192	18.80	34.91	25.02		0.64
281	11.52	34.20	26.08		1.52
281					1.57 1/
368	08.79 2/	34.14	26.50		2.25
368	08.85 2/	34.14	26.49		
458	07.36	34.20	26.76		2.83
545	06.02	34.23	26.96		3.15
722	04.96	34.42	27.24		3.39
904	04.38	34.47	27.35		3.27
1097	03.84	34.47	27.40		3.40
1097					3.34 1/

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	26.68	34.88	22.75	0.000	1.875
10	26.61	34.88	22.77	0.051	1.824
20	26.59	34.88	22.77	0.102	1.773
30	26.56	34.87	22.78	0.153	1.722
50	26.41	34.87	22.82	0.254	1.621
75	26.00	34.86	22.94	0.380	1.495
100	23.60	34.92	23.71	0.494	1.381
150	21.15	35.03	24.49	0.687	1.188
200	18.19	34.85	25.12	0.848	1.027
250	14.73	34.47	25.64	0.981	0.894
300	10.65	34.17	26.21	1.089	0.786
400	08.24	34.14	26.58	1.260	0.615
500	06.69	34.22	26.86	1.399	0.476
600	05.56	34.29	27.06	1.516	0.359
700	05.06	34.40	27.21	1.617	0.258
800	04.69	34.45	27.29	1.708	0.167
1000	04.09	34.47	27.37	1.875	0.000

1/ Values do not agree within 0.02 µg at/l tolerance. Average value used in constructing phosphate-temperature curve.

2/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-depth curve.

STATION 10

M/V Hugh M. Smith: Cruise 12, 20°18'N., 158°22'W., October 27, 1951. Messenger time: 0254 GCT. Weather: 02, cloud coverage 7. Wind: 180°, 11 kt. Sea: 1-3 ft. Wire angle: 31°. Depth of water: 2520 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.80	34.86	22.69		0.34
09	26.75	34.86	22.71		0.31
09					0.38 1/
25	26.70	34.86	22.73		0.40
25					0.33 1/
49	26.38	34.82	22.80		0.36
98	23.45	34.87	23.73		0.33
98					0.41 1/
192	18.65	34.91	25.06		0.65
281	12.01	34.25	26.02		1.44
281					1.49 1/
369	08.91 2/	34.13	26.47		2.10
369	08.98 2/	34.13	26.46		
458	07.45	34.18	26.73		2.77
546	06.24	34.25	26.95		3.16
729	05.01	34.42	27.24		3.29
915	04.34	34.46	27.34		3.19
1105	03.74	34.43	27.39		3.24

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	26.83	34.86	22.68	0.000	1.873
10	26.74	34.86	22.71	0.052	1.821
20	26.71	34.86	22.72	0.103	1.770
30	26.68	34.86	22.73	0.154	1.719
50	26.35	34.82	22.80	0.257	1.616
75	24.99	34.83	23.23	0.379	1.494
100	23.38	34.88	23.75	0.489	1.384
150	21.08	35.03	24.51	0.681	1.192
200	18.00	34.84	25.16	0.840	1.033
250	14.10	34.42	25.73	0.970	0.903
300	11.00	34.19	26.16	1.077	0.796
400	08.39	34.14	26.56	1.251	0.622
500	06.82	34.21	26.84	1.393	0.480
600	05.83	34.32	27.05	1.512	0.361
700	05.19	34.40	27.19	1.614	0.259
800	04.67	34.46	27.30	1.705	0.168
1000	04.12	34.46	27.36	1.873	0.000

1/ Values do not agree within 0.02 µg at/l tolerance. Average value used in constructing phosphate-temperature curve.

2/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-depth curve.

STATION 11

M/V Hugh M. Smith: Cruise 12, 18°47'N., 157°27'W., October 27, 1951. Messenger time: 1724 GCT. Weather: 00, cloud coverage 6. Wind: 160°, 19 kt. Sea: 5-8 ft. Wire angle: 00°. Depth of water: 2450 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.50	34.79	22.74		0.18
10	26.49	34.78	22.74		0.27
30	26.26	34.83	22.84		0.21
59	26.06	34.79	22.88		0.34
119	22.74	35.00	24.03		0.30
237	14.22	34.36	25.66		1.04
353	08.89	34.19	26.52		2.22
466	07.75	34.30	26.78		2.71
583	06.68	34.35	26.97		2.98
695	05.78	34.37	27.10		3.14
924	04.61	34.42	27.28		3.12
1142	03.92	34.50	27.42		3.04
1352	03.28	34.52	27.50		3.02

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	26.50	34.79	22.73	0.000	1.901
10	26.49	34.78	22.73	0.051	1.850
20	26.39	34.80	22.78	0.102	1.799
30	26.26	34.83	22.84	0.153	1.748
50	26.11	34.80	22.86	0.254	1.647
75	25.52	34.81	23.06	0.377	1.524
100	23.68	34.91	23.68	0.491	1.410
150	21.80	35.11	24.37	0.687	1.214
200	18.50	34.90	25.09	0.851	1.050
250	13.32	34.31	25.81	0.982	0.919
300	10.05	34.18	26.32	1.082	0.819
400	08.40	34.23	26.62	1.245	0.656
500	07.41	34.33	26.85	1.384	0.517
600	06.52	34.35	26.99	1.506	0.395
700	05.74	34.37	27.10	1.617	0.284
800	05.19	34.39	27.19	1.718	0.183
1000	04.36	34.45	27.33	1.901	0.000

STATION 12

M/V Hugh M. Smith: Cruise 12, 19°28'N., 157°27'W., October 28, 1951. Messenger time: 0037 GCT. Weather: 00, cloud coverage 9. Wind: 180°, 18 kt. Sea: 5-8 ft. Wire angle: 07°. Depth of water: 2300 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.10	34.86	22.92		0.28
10	26.10	34.87	22.93		0.30
10					0.35 1/
31	26.08	34.86	22.92		0.31
31					0.36 1/
61	24.54	34.89	23.41		0.27
61					0.38 1/
119	21.78	35.12	24.39		0.34
119					0.39 1/
234	13.58	34.33	25.78		1.22
346	08.81	34.17	26.52		2.25
346					2.34 1/
453	06.87	34.22	26.84		2.93
453					2.88 1/
564	06.12	34.34	27.04		3.13
564					3.19 1/
673	05.59	34.35	27.11		3.26
673					3.21 1/
894	04.66	34.49	27.33		3.24
1107	03.96	34.43	27.36		3.22
1107					3.14 1/
1314	03.36	34.59	27.54		1.79

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	26.10	34.86	22.91	0.000	1.774
10	26.10	34.87	22.92	0.050	1.724
20	26.10	34.87	22.92	0.099	1.675
30	26.08	34.86	22.92	0.149	1.625
50	25.60	34.88	23.08	0.246	1.528
75	23.89	34.90	23.61	0.360	1.414
100	22.78	35.00	24.01	0.463	1.311
150	19.55	35.03	24.92	0.639	1.135
200	15.46	34.52	25.51	0.780	0.994
250	12.78	34.26	25.88	0.898	0.876
300	10.40	34.16	26.24	0.999	0.775
400	07.53	34.19	26.72	1.161	0.613
500	06.46	34.32	26.97	1.288	0.486
600	05.88	34.35	27.07	1.400	0.374
700	05.47	34.37	27.14	1.504	0.270
800	05.01	34.46	27.26	1.600	0.174
1000	04.34	34.46	27.34	1.774	0.000

1/ Values do not agree within 0.02 µg at/l tolerance. Average value used in constructing phosphate-temperature curve.

STATION 13

M/V Hugh M. Smith: Cruise 12, 20°06'N., 157°28'W., October 28, 1951. Messenger time: 0747 GCT. Weather: 00, cloud coverage not recorded. Wind: 150°, 19 kt. Sea: 5-8 ft. Wire angle: 09°. Depth of water: 2260 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.10	34.85	22.90		0.18
09	26.12	34.85	22.90		0.21
28	26.13	34.84	22.89		0.23
55	26.02	34.85	22.93		0.24
111	22.82	34.93	23.96		0.36
214	17.18	34.75	25.30		0.48
314	10.58	34.17	26.22		1.77
412	07.98	34.19	26.66		2.55
412					2.53 1/
513	06.60	34.24	26.90		2.95
611	06.18	34.36	27.05		3.07
611					3.12 1/
812	04.92	34.46	27.28		3.17
1010	04.30	34.48	27.36		3.13
1207	03.64	34.50	27.45		3.16

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	26.12	34.85	22.90	0.000	1.881
10	26.12	34.85	22.90	0.050	1.831
20	26.13	34.84	22.89	0.099	1.782
30	26.13	34.84	22.89	0.149	1.732
50	26.07	34.85	22.91	0.249	1.632
75	25.37	34.86	23.14	0.371	1.510
100	23.25	34.91	23.81	0.482	1.399
150	21.50	35.08	24.43	0.674	1.207
200	18.20	34.88	25.14	0.835	1.046
250	14.10	34.37	25.69	0.967	0.914
300	11.11	34.19	26.14	1.075	0.806
400	08.22	34.18	26.61	1.247	0.634
500	06.70	34.23	26.87	1.385	0.496
600	06.27	34.34	27.01	1.505	0.376
700	05.62	34.38	27.13	1.613	0.268
800	04.99	34.45	27.26	1.709	0.172
1000	04.31	34.49	27.36	1.881	0.000

1/ Values do not agree within 0.02 µg at/l tolerance. Average value used in constructing phosphate-temperature curve.

STATION 14

M/V Hugh M. Smith: Cruise 12, 20°40'N., 157°28'W., October 28, 1951. Messenger time: 1451 GCT. Weather: 00, cloud coverage not recorded. Wind: 140°, 16 kt. Sea: 3-5 ft. Wire angle: 00°. Depth of water: 2150 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.20	34.86	22.88		0.24
10	26.18	34.86	22.89		0.26
30	26.21	34.86	22.88		0.29
60	25.63	34.87	23.07		0.31
60					0.36 1/
120	20.56	34.99	24.62		0.40
120					0.46 1/
239	14.60	34.43	25.64		1.05
355	09.85	34.14	26.32		1.95
355					1.86 1/
469	07.20	34.19	26.78		2.73
585	05.92	34.26	27.00		3.03
697	05.46	34.35	27.13		3.15
926	04.46	34.43	27.31		3.15
1147	03.84	34.46	27.39		3.10
1357	03.29	34.50	27.48		3.09

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D 1000 - \Delta D$ (dyn. m)
00	26.22	34.86	22.88	0.000	1.867
10	26.18	34.86	22.89	0.050	1.817
20	26.19	34.86	22.88	0.100	1.767
30	26.21	34.86	22.88	0.150	1.717
50	25.88	34.86	22.98	0.249	1.618
75	25.20	34.86	23.19	0.369	1.498
100	23.30	34.90	23.79	0.480	1.387
150	18.98	34.90	24.96	0.660	1.207
200	16.70	34.68	25.35	0.803	1.064
250	13.98	34.39	25.73	0.929	0.938
300	11.68	34.22	26.06	1.038	0.829
400	08.63	34.13	26.51	1.219	0.648
500	06.73	34.20	26.84	1.363	0.504
600	05.85	34.27	27.01	1.484	0.383
700	05.45	34.35	27.12	1.592	0.275
800	04.98	34.40	27.22	1.690	0.177
1000	04.19	34.45	27.35	1.867	0.000

1/ Values do not agree within ~~X~~. 0.02 µg at/l tolerance. Average value used in constructing phosphate-temperature curve.

STATION 15

M/V Hugh M. Smith: Cruise 12, 21°05'N., 157°28'W., October 28, 1951. Messenger time: 1925 GCT. Weather: 01, cloud coverage 4. Wind: 140°, 16 kt. Sea: 3-5 ft. Wire angle: 00°. Depth of water: 30 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.20	34.89	22.91		0.37
10	26.18	34.87	22.90		0.36
26	26.12	34.88	22.93		0.35
35	26.08	34.88	22.94		0.37

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	26.20	34.89			
10	26.18	34.87			
20	26.13	34.88			
30	26.09	34.88			

STATION 16

M/V Hugh M. Smith: Cruise 12, 21°17'N., 157°25'W., October 28, 1951. Messenger time: 2231 GCT. Weather: 01, cloud coverage 4. Wind: 140°, 16 kt. Sea: 3-5 ft. Wire angle: 09°. Depth of water: 300 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.10	34.79	22.87		0.30
10	26.04	34.84	22.92		0.30
25	25.92	34.82	22.95		0.32
49	25.78	34.85	23.01		0.35
98	23.18	35.01	23.91		0.41
98					0.36 2/
196	18.47	34.88	25.08		0.60
292	10.98	34.16	26.15		1.49
389	08.23 1/	34.12	26.57		2.16
389	08.29 1/	34.12	26.56		
487	06.71	34.21	26.86		2.63

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	26.07	34.79			
10	26.04	34.84			
20	25.97	34.82			
30	25.88	34.82			
50	25.77	34.85			
75	24.08	34.93			
100	22.96	35.04			
150	20.60	35.14			
200	18.28	34.87			
250	14.05	34.39			
300	10.65	34.14			
400	08.12	34.12			
500	06.58	34.21			

1/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-depth curve.

2/ Values do not agree within 0.02 µg at/l tolerance. Average value used in constructing phosphate-temperature curve.

STATION 17

M/V Hugh M. Smith: Cruise 12, 21°48'N., 157°29'W., October 29, 1951. Messenger time: 0535 GCT. Weather: 00, cloud coverage 8. Wind: 140°, 16 kt. Sea: 3-5 ft. Wire angle: 23°. Depth of water: 1900 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.80	34.81	22.96		0.36
09	25.84	34.79	22.94		0.34
27	25.67	34.79	23.00		0.39
54	25.66	34.85	23.05		0.48
105	22.89	34.98	23.97		0.41
203	19.71	35.18	24.99		0.49
295	11.68	34.20	26.05		1.30
383	09.02 1/	34.09	26.42		2.05
383	09.08 1/	34.09	26.41		2.01
476	07.10	34.10	26.72		2.72
565	06.04	34.18	26.92		3.02
755	04.95	34.34	27.18		3.23
946	04.29	34.46	27.35		3.08
1145	03.76	34.42	27.37		3.11
1145					3.07 1/

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	25.83	34.81	22.96	0.000	1.918
10	25.84	34.79	22.94	0.049	1.869
20	25.73	34.79	22.98	0.098	1.820
30	25.65	34.79	23.00	0.147	1.771
50	25.67	34.84	23.03	0.245	1.673
75	25.25	34.87	23.18	0.364	1.554
100	23.07	34.96	23.90	0.474	1.444
150	21.55	35.23	24.53	0.662	1.256
200	19.82	35.19	24.97	0.825	1.093
250	16.00	34.62	25.47	0.966	0.952
300	11.40	34.18	26.08	1.081	0.837
400	08.67	34.08	26.47	1.264	0.654
500	06.71	34.13	26.79	1.412	0.506
600	05.79	34.21	26.97	1.537	0.381
700	05.21	34.30	27.11	1.647	0.271
800	04.73	34.40	27.25	1.745	0.173
1000	04.19	34.46	27.35	1.918	0.000

1/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-depth curve.

2/ Values do not agree within 0.02 µg at/l tolerance. Average value used in constructing phosphate-temperature curve.

STATION 18

M/V Hugh M. Smith: Cruise 12, 22°12'N., 157°31'W., October 29, 1951. Messenger time: 0900 GCT. Weather: 00, cloud coverage 3. Wind: 130°, 12 kt. Sea: 5-8 ft. Wire angle: 24°. Depth of water: 2560 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.70	34.67	22.89		0.35
00					0.40 1/
09	25.72	34.68	22.90		0.32
27	25.56	34.75	23.00		0.30
27					0.39 1/
54	25.56	34.74	22.99		0.33
107	22.46	34.95	24.07		0.38
107					0.47 1/
209	18.36	35.01	25.09		0.44
307	12.20	34.16	25.92		1.29
307					1.34 1/
402	08.74	34.10	26.47		2.06
402					2.10 1/
501	06.49	34.05	26.76		2.62
597	05.71	34.13	26.92		3.03
800	04.67	34.34	27.21		3.19
1013	03.97	34.48	27.40		3.03
1229	03.40	34.39	27.38		2.92

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	25.73	34.67	22.88	0.000	1.938
10	25.72	34.68	22.90	0.050	1.888
20	25.62	34.73	22.96	0.099	1.839
30	25.55	34.75	23.00	0.148	1.790
50	25.55	34.74	22.99	0.246	1.692
75	25.15	34.78	23.15	0.367	1.571
100	22.96	34.90	23.88	0.477	1.461
150	21.12	35.20	24.63	0.663	1.275
200	19.20	35.06	25.03	0.822	1.116
250	15.50	34.52	25.51	0.961	0.977
300	12.50	34.19	25.88	1.080	0.858
400	08.85	34.10	26.45	1.273	0.665
500	06.49	34.05	26.76	1.424	0.514
600	05.68	34.14	26.93	1.552	0.386
700	05.14	34.24	27.07	1.665	0.273
800	04.67	34.35	27.21	1.766	0.172
1000	03.98	34.48	27.39	1.938	0.000

1/ Values do not agree within 0.02 µg at/l tolerance. Average value used in constructing phosphate-temperature curve.

STATION 19

M/V Hugh M. Smith: Cruise 12, 21°50'N., 156°47'W., October 29, 1951. Messenger time: 1655 GCT. Weather: 00, cloud coverage 10. Wind: 190°, 13 kt. Sea: 5-8 ft. Wire angle: 08°. Depth of water: 2680 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.70	34.78	22.97		0.33
10	25.73	34.81	22.99		0.34
30	25.75	34.82	22.99		0.31
60	25.75	34.81	22.99		0.47
119	22.53	35.02	24.10		0.41
235	18.00	34.88	25.20		0.56
348	09.96	34.07	26.25		1.70
458	07.88	34.17	26.66		2.61
571	06.33	34.23	26.92		3.08
681	05.24	34.29	27.10		3.23
906	04.61	34.42	27.28		3.22
1124	04.00	34.45	27.38		3.19
1338	03.34	34.51	27.48		3.07
1338					3.12 1/

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	25.73	34.78	22.97	0.000	1.951
10	25.73	34.81	22.99	0.049	1.902
20	25.74	34.82	22.99	0.098	1.853
30	25.75	34.82	22.99	0.147	1.804
50	25.75	34.81	22.98	0.245	1.706
75	25.73	34.83	23.01	0.367	1.584
100	23.65	34.92	23.70	0.481	1.470
150	21.46	35.19	24.53	0.674	1.277
200	19.40	35.11	25.02	0.836	1.115
250	16.95	34.73	25.33	0.979	0.972
300	11.70	34.14	25.99	1.100	0.851
400	08.86	34.11	26.46	1.287	0.664
500	07.23	34.20	26.77	1.437	0.514
600	05.96	34.24	26.97	1.563	0.388
700	05.16	34.30	27.12	1.673	0.278
800	04.87	34.38	27.22	1.771	0.180
1000	04.41	34.45	27.32	1.951	0.000

1/ Values do not agree within 0.02 µg at/l tolerance. Average value used in constructing phosphate-temperature curve.

STATION 20

M/V Hugh M. Smith: Cruise 12, 21°10'N., 156°35'W., October 29, 1951. Messenger time: 2334 GCT. Weather: 00, cloud coverage 10. Wind: 150°, 8 kt. Sea: 1-3 ft. Wire angle: 02°. Depth of water: 256 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.70	34.84	23.03		0.27
10	25.70	34.84	23.03		0.28
25	25.72	34.84	23.02		0.36
50	25.72	34.87	23.04		0.36
101	22.44	35.00	24.11		0.39
201	17.31	34.76	25.27		0.54
300	11.20	34.14	26.09		1.34

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	25.72	34.84			
10	25.70	34.84			
20	25.71	34.84			
30	25.72	34.84			
50	25.72	34.87			
75	25.65	34.88			
100	22.44	35.00			
150	20.37	35.18			
200	17.32	34.78			
250	12.63	34.24			
300	11.20	34.14			

STATION 21

M/V Hugh M. Smith: Cruise 12, 20°49'N., 156°45'W., October 30, 1951. Messenger time: 0337 GCT. Weather: 00, cloud coverage 10. Wind: direction not recorded, 14 kt. Sea: 1-3 ft. Wire angle: 00°. Depth of water: 35 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.80	34.58	22.79		0.40
10	25.84	34.81	22.96		0.39
25	25.48	34.82	23.08		0.49

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	25.82	34.58			
10	25.84	34.81			
20	25.66	34.82			
30	25.35	34.82			

STATION 22

M/V Hugh M. Smith: Cruise 12, 20°22'N., 156°39'W., October 30, 1951. Messenger time: 0808 GCT. Weather: 00, cloud coverage 10. Wind: 070°, 22 kt. Sea: 1-3 ft. Wire angle: 26°. Depth of water: 1220 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.50	34.75	22.71		0.33
09	26.48	34.75	22.72		0.34
27	26.50	34.83	22.77		0.35
55	25.86	34.82	22.96		0.32
108	22.95	35.06	24.02		0.34
211	18.76	34.89	25.02		0.50
313	10.41	34.15	26.24		1.82
406	08.54	34.21	26.60		2.45
506	07.06	34.24	26.83		2.94
601	06.08	34.32	27.03		3.13
800	05.05	34.40	27.22		3.13
1002	04.16	34.45	27.36		3.06
1207	03.62	34.43	27.39		3.06

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	26.49	34.75	22.71	0.000	1.906
10	26.48	34.75	22.71	0.051	1.855
20	26.50	34.80	22.74	0.103	1.803
30	26.49	34.83	22.77	0.154	1.752
50	26.26	34.84	22.85	0.255	1.651
75	25.45	34.85	23.11	0.378	1.528
100	23.65	34.98	23.75	0.491	1.415
150	21.15	35.18	24.60	0.680	1.226
200	19.41	34.98	24.91	0.843	1.063
250	14.20	34.40	25.70	0.980	0.926
300	10.77	34.16	26.18	1.087	0.819
400	08.65	34.21	26.57	1.260	0.646
500	07.14	34.24	26.82	1.402	0.504
600	06.08	34.32	27.02	1.524	0.382
700	05.50	34.37	27.13	1.631	0.275
800	05.05	34.41	27.22	1.730	0.176
1000	04.16	34.46	27.36	1.906	0.000

STATION 23

M/V Hugh M. Smith: Cruise 12, 19°44'N., 156°44'W., October 30, 1951. Messenger time: first cast 1453 GCT, second cast 1553 GCT. Weather: not recorded, cloud coverage 8. Wind: 220°, 16 kt. Sea: 1-3 ft. Wire angle: first cast 48°, second cast 62°. Depth of water: 2525 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (μg at/l)
00	26.10	34.86	22.91		0.25
07	26.12	34.83	22.89		0.31
19	26.14	34.83	22.88		0.29
36	25.37	34.86	23.14		0.28
68	23.21	34.97	23.87		0.35
129	19.74	35.12	24.94		0.46
183	16.33	34.63	25.41		0.72
233	13.58	34.32	25.77		1.30
282	10.52	34.14	26.21		1.85
325	09.02	34.18	26.49		2.21
424	07.04	34.19	26.80		2.82
514	06.40	34.34	27.00		2.87
645	05.80	34.38	27.11		3.10
633	05.71	34.43	27.16		2.87
912	04.49	34.31	27.21		3.18

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	26.13	34.86	22.90	0.000	1.731
10	26.13	34.83	22.88	0.050	1.681
20	26.13	34.83	22.88	0.100	1.631
30	26.01	34.84	22.93	0.149	1.582
50	24.00	34.92	23.60	0.242	1.489
75	22.90	35.01	23.99	0.346	1.385
100	21.53	35.22	24.53	0.438	1.293
150	18.72	34.96	25.08	0.598	1.133
200	15.23	34.50	25.55	0.734	0.997
250	12.60	34.24	25.90	0.850	0.881
300	09.80	34.14	26.33	0.949	0.782
400	07.35	34.19	26.75	1.105	0.626
500	06.50	34.34	26.98	1.230	0.501
600	06.03	34.36	27.06	1.342	0.389
700	05.37	34.42	27.19	1.445	0.286
800	04.91	34.36	27.20	1.541	0.190
1000	04.20	34.31	27.23	1.731	0.000

STATION 24

M/V Hugh M. Smith: Cruise 12, 19°04'N., 156°38'W., October 31, 1951. Messenger time: 0042 GCT. Weather: not recorded, cloud coverage 7. Wind: 160°, 13 kt. Sea: 1-3 ft. Wire angle: 32°. Depth of water: 2580 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.40	34.78	22.77		0.28
09	26.28	34.77	22.79		0.26
25	26.08	34.79	22.87		0.31
49	25.23	34.86	23.19		0.26
97	22.56	34.98	24.06		0.33
187	16.08	34.61	25.45		0.68
277	10.04	34.13	26.29		1.77
363	08.55 1/	34.28	26.64		2.66
363	08.61 1/	34.28	26.63		
453	07.38	34.35	26.87		3.00
540	06.69	34.38	27.00		3.08
726	05.51	34.42	27.18		3.22
917	04.64	34.45	27.30		3.09
1115	04.00	34.47	27.39		3.12

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D 1000 - \Delta D$ (dyn. m)
00	26.36	34.78	22.77	0.000	1.757
10	26.27	34.77	22.79	0.051	1.706
20	26.12	34.78	22.85	0.101	1.656
30	26.00	34.80	22.90	0.151	1.606
50	25.22	34.86	23.18	0.248	1.509
75	23.82	34.92	23.65	0.361	1.396
100	22.15	35.05	24.23	0.461	1.296
150	19.07	35.03	25.04	0.628	1.129
200	14.23	34.39	25.68	0.762	0.995
250	11.40	34.16	26.06	0.871	0.886
300	09.62	34.16	26.38	0.965	0.792
400	08.06	34.31	26.74	1.119	0.638
500	07.97	34.37	26.80	1.255	0.502
600	06.30	34.40	27.06	1.377	0.380
700	05.62	34.42	27.16	1.481	0.276
800	05.17	34.43	27.22	1.578	0.179
1000	04.32	34.46	27.34	1.757	0.000

1/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-depth curve.

STATION 25

M/V Hugh M. Smith: Cruise 12, 18°21'N., 156°38'W., October 31, 1951. Messenger time: 0742 GCT. Weather: 00, cloud coverage 5. Wind: 220°, 6 kt. Sea: not recorded. Wire angle: 00°. Depth of water: 2600 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.30	34.78	22.80		0.28
10	26.25	34.77	22.80		0.29
25	26.16	34.81	22.86		0.29
55	26.18	34.82	22.86		0.35
110	25.03	34.80	23.20		0.36
219	16.13	34.44	25.31		0.98
328	09.40	34.22	26.46		2.25
441	07.38	34.20	26.76		2.74
548	06.42	34.32	26.98		3.08
655	05.80	34.41	27.13		3.10
866	04.86	34.43	27.26		3.20
1076	04.04	34.49	27.40		3.16
1277	03.46	34.51	27.47		3.16

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	26.28	34.78	22.80	0.000	1.904
10	26.25	34.77	22.80	0.051	1.853
20	26.19	34.80	22.84	0.101	1.803
30	26.13	34.81	22.87	0.151	1.753
50	26.17	34.82	22.86	0.252	1.652
75	26.07	34.82	22.89	0.377	1.527
100	25.68	34.81	23.01	0.501	1.403
150	21.43	35.00	24.39	0.713	1.191
200	18.42	34.75	24.99	0.879	1.025
250	13.21	34.30	25.82	1.011	0.893
300	10.40	34.24	26.31	1.112	0.792
400	07.99	34.20	26.66	1.274	0.630
500	06.78	34.24	26.87	1.409	0.495
600	06.12	34.38	27.06	1.527	0.377
700	05.56	34.42	27.17	1.630	0.274
800	05.11	34.43	27.23	1.727	0.177
1000	04.40	34.47	27.34	1.904	0.000

STATION 26

M/V Hugh M. Smith: Cruise 12, 18°03'N., 155°33'W., October 31, 1951. Messenger time: 1700 GCT. Weather: 00, cloud coverage 5. Wind: 110°, 12 kt. Sea: 1-3 ft. Wire angle: 00°. Depth of water: 2625 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.60	1/			0.34
10	25.84	34.69	22.87		0.35
10					0.41 2/
25	25.84	34.71	22.88		0.40
55	25.77	34.84	23.00		0.39
109	21.94	34.97	24.23		0.40
217	13.93	34.27	25.66		1.43
324	09.01	34.12	26.45		2.16
437	07.68 3/	34.34	26.82		2.96
437	07.72 3/	34.34	26.82		
544	06.70	34.39	27.00		3.14
652	05.88	34.42	27.13		3.23
864	04.83	34.47	27.30		3.28
864					3.33
1079	03.96	34.49	27.41		3.18
1288	03.39	34.55	27.50		3.14

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D 1000 - \Delta D$ (dyn. m)
00	25.64	34.69	22.93	0.000	1.794
10	25.84	34.69	22.87	0.050	1.744
20	25.84	34.70	22.87	0.100	1.694
30	25.84	34.73	22.90	0.150	1.644
50	25.79	34.83	22.99	0.248	1.546
75	25.62	34.85	23.05	0.370	1.424
100	22.32	34.94	24.10	0.479	1.315
150	20.55	34.99	24.62	0.660	1.134
200	15.60	34.40	25.39	0.811	0.983
250	11.31	34.12	26.05	0.927	0.867
300	09.48	34.09	26.34	1.021	0.773
400	08.09	34.28	26.71	1.179	0.615
500	07.08	34.37	26.93	1.310	0.484
600	06.24	34.41	27.07	1.424	0.370
700	05.55	34.44	27.18	1.526	0.268
800	05.09	34.47	27.26	1.621	0.173
1000	04.38	34.48	27.35	1.794	0.000

1/ No sample.

2/ Values do not agree within 0.02 µg at/l tolerance. Average value used in constructing phosphate-temperature curve.

3/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-depth curve.

STATION 27

M/V Hugh M. Smith: Cruise 12, 18°40'N., 154°28'W., November 1, 1951. Messenger time: 0255 GCT. Weather: 00, cloud coverage 5. Wind: 060°, 10 kt. Sea: 1-3 ft. Wire angle: 22°. Depth of water: 2900 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	26.10	34.65	22.76		0.35
09	26.06	34.62	22.75		0.33
23	25.92	34.70	22.85		0.36
45	25.88	34.74	22.89		0.42
91	25.03	34.78	23.19		0.43
185	18.06	34.69	25.04		0.73
273	10.70	34.23	26.25		2.03
367	08.89 1/	34.40	26.69		2.72
367	08.95 1/	34.40	26.67		
455	07.65	34.39	26.87		2.99
548	06.80	34.42	27.01		3.11
732	05.62	34.44	27.18		3.23
916	04.74	34.45	27.29		3.19
1114	04.09	34.43	27.35		3.02

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D_{1000} - \Delta D$ (dyn. m)
00	26.09	34.65	22.76	0.000	1.835
10	26.06	34.62	22.74	0.051	1.784
20	25.98	34.68	22.81	0.102	1.733
30	25.90	34.71	22.86	0.152	1.683
50	25.88	34.74	22.89	0.252	1.583
75	25.88	34.74	22.89	0.377	1.458
100	23.90	34.82	23.55	0.495	1.340
150	20.38	34.92	24.61	0.689	1.146
200	16.82	34.58	25.25	0.843	0.992
250	11.60	34.25	26.10	0.962	0.873
300	10.12	34.28	26.38	1.054	0.781
400	08.41	34.39	26.75	1.208	0.627
500	07.23	34.41	26.94	1.337	0.498
600	06.44	34.43	27.06	1.452	0.383
700	05.80	34.44	27.15	1.556	0.279
800	05.27	34.45	27.22	1.654	0.181
1000	04.44	34.44	27.31	1.835	0.000

1/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-depth curve.

STATION 28

M/V Hugh M. Smith: Cruise 12, 19°16'N., 154°32'W., November 1, 1951. Messenger time: 0849 GCT. Weather: 20, cloud coverage 10. Wind: 080°, 9 kt. Sea: 1-3 ft. Wire angle: 18°. Depth of water: 2800 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.90	34.87	22.97		0.36
10	25.96	34.82	22.93		0.38
24	25.76	34.87	23.03		0.39
51	25.66	34.87	23.06		0.39
103	25.48	34.89	23.13		0.37
203	17.38	34.52	25.07		0.81
301	10.52	2/			2.47
405	07.80 1/	34.20	26.70		2.66
405	07.86 1/	34.20	26.69		2.71
505	06.80	34.24	26.87		2.95
505					3.00 3/
604	06.14	34.36	27.05		3.12
799	05.00	34.44	27.26		3.24
999	04.52	34.46	27.31		3.17
1195	03.78	34.48	27.42		3.17
1195					3.12 3/

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	25.94	34.87	22.97	0.000	1.896
10	25.96	34.82	22.93	0.049	1.847
20	25.82	34.87	23.01	0.098	1.798
30	25.71	34.87	23.04	0.147	1.749
50	25.66	34.87	23.06	0.244	1.652
75	25.58	34.88	23.09	0.364	1.532
100	25.50	34.88	23.11	0.484	1.412
150	21.62	34.77	24.16	0.700	1.196
200	17.50	34.53	25.05	0.870	1.026
250	12.42	34.23	25.93	0.998	0.898
300	10.52	34.20	26.25	1.097	0.799
400	07.96	34.20	26.67	1.261	0.635
500	06.84	34.23	26.85	1.397	0.499
600	06.18	34.36	27.04	1.517	0.379
700	05.59	34.41	27.15	1.622	0.274
800	05.00	34.44	27.25	1.718	0.178
1000	04.51	34.46	27.32	1.896	0.000

1/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-depth curve.

2/ No sample.

3/ Values do not agree within 0.02 µg at/l tolerance. Average value used in constructing phosphate-temperature curve.

STATION 29

M/V Hugh M. Smith: Cruise 12, 20°04'N., 154°33'W., November 1, 1951. Messenger time: 1532 GCT. Weather: 00, cloud coverage 4. Wind: 080°, 6 kt. Sea: 1-3 ft. Wire angle: 08°. Depth of water: 3000 f.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.40	34.48	22.83		0.25
10	25.45	34.46	22.82		0.24
25	25.54	34.52	22.83		0.28
54	25.62	34.77	23.00		0.33
108	21.96	34.79	24.09		0.33
213	15.08	34.37	25.49		1.06 1/
213					1.11
318	09.85	34.14	26.33		1.86
426	08.10 2/	3/			2.64
426	08.16 2/				
529	06.31	34.22	26.92		2.93
633	05.39	34.29	27.09		3.04
837	04.83	34.42	27.26		3.16
1042	04.13	34.44	27.35		3.03
1240	03.55	34.50	27.45		3.11

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	ΔD 1000 - ΔD (dyn. m)
00	25.44	34.48	22.83	0.000	1.840
10	25.45	34.46	22.81	0.050	1.790
20	25.52	34.48	22.81	0.101	1.739
30	25.58	34.57	22.86	0.151	1.689
50	25.62	34.76	22.99	0.251	1.589
75	24.00	34.80	23.51	0.367	1.473
100	22.66	34.79	23.89	0.473	1.367
150	19.55	34.71	24.67	0.658	1.182
200	16.50	34.46	25.23	0.811	1.029
250	12.47	34.19	25.88	0.935	0.905
300	10.21	34.14	26.26	1.036	0.804
400	08.54	34.17	26.56	1.205	0.635
500	06.75	34.20	26.84	1.347	0.493
600	05.64	34.27	27.04	1.466	0.374
700	05.08	34.40	27.21	1.569	0.271
800	04.88	34.42	27.25	1.662	0.178
1000	04.37	34.43	27.31	1.840	0.000

1/ Values do not agree within 0.02 µg at/l tolerance. Average value used in constructing phosphate-temperature curve.

2/ Values do not agree within 0.02°C tolerance. Average value used in constructing temperature-depth curve.

3/ No sample.

STATION 30

M/V Hugh M. Smith: Cruise 12, 20°38'N., 154°28'W., November 1, 1951. Messenger time: 2106 GCT. Weather: 00, cloud coverage 5. Wind: 080°, 9 kt. Sea: 1-3 ft. Wire angle: 19°. Depth of water: no data.

OBSERVED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	O_2 (ml/l)	PO_4-P (µg at/l)
00	25.70	34.62	22.85		0.19
09	25.71	34.66	22.89		0.23
23	25.75	34.73	22.93		0.31
52	25.71	34.86	23.04		0.25
101	23.18	34.75	23.71		0.33
198	16.09	34.43	25.31		0.88
297	10.86	34.11	26.13		1.54
398	08.91 1/	34.25	26.56		2.53
398	08.97 1/	34.25	26.55		
495	07.20	34.30	26.86		2.90
594	06.39	34.32	26.99		3.02
788	05.24	34.35	27.15		3.16
989	04.43	34.42	27.30		3.04
1191	03.72	34.47	27.41		3.10

INTERPOLATED AND CALCULATED

DEPTH (m)	T (°C)	S (°/oo)	σ_t	ΔD (dyn. m)	$\Delta D\,1000 - \Delta D$ (dyn. m)
00	25.73	34.62	22.85	0.000	1.895
10	25.71	34.67	22.89	0.050	1.845
20	25.74	34.72	22.92	0.100	1.795
30	25.74	34.77	22.96	0.149	1.746
50	25.72	34.86	23.03	0.247	1.648
75	25.62	34.87	23.07	0.368	1.527
100	23.50	34.76	23.62	0.482	1.413
150	19.62	34.70	24.65	0.674	1.221
200	15.95	34.43	25.33	0.825	1.070
250	12.55	34.19	25.87	0.948	0.947
300	10.80	34.11	26.13	1.051	0.844
400	08.90	34.25	26.56	1.227	0.668
500	07.16	34.30	26.86	1.368	0.527
600	06.35	34.32	26.99	1.489	0.406
700	05.78	34.33	27.07	1.601	0.294
800	05.21	34.35	27.15	1.706	0.189
1000	04.40	34.42	27.30	1.895	0.000

1/ Thermometers did not agree within 0.02°C tolerance. Average value used in constructing temperature-depth curve.

DIVIDENDS FROM RESEARCH

THE BIRTH OF A FISHERY

Donald L. McKernan
U. S. Fish and Wildlife Service
Honolulu, Hawaii

Organized as the Pacific Oceanic Fishery Investigations, a unit of the U. S. Fish and Wildlife Service with headquarters in Honolulu, we have been investigating the potential fishery resources of the central Pacific, an area of nearly 7 million square miles, from approximately 30° N. to 10° S. latitude and from 110° W. longitude to 180°. Our efforts have been concentrated on locating pelagic, oceanic areas with favorable conditions for biological productivity and systematically searching such areas for concentrations of fish.

Two research methods are being used to attain those objectives. First, we have depended upon biological and physical oceanography to define the regions of potential productivity. The movement of major water masses, including current boundaries, vertical motion, and measures of inorganic nutrient salts in the sea--all have provided clues to areas of high biological productivity. Second, after finding promising environments in the open sea, we have sampled the fish populations, using accepted commercial fishing techniques as well as the biological sampling methods necessary for capturing the smaller, more elusive fishes.

Using these methods, we have found evidences of upwelling associated with a divergence at or near the Equator about 1,200 miles south of Hawaii. This upwelling enriches the euphotic zone by bringing up inorganic salts from the deeper waters. Plankton and midwater trawl samples, when compared with similar samples from other pelagic tropical waters, contain unusually large amounts of organisms. Experimental fishing by various means demonstrated the existence of an extensive concentration of yellowfin tuna, its center of abundance lying in a band from about 140° to 170° W. longitude and from 5° N. latitude to the Equator, an area of about 500,000 square miles.

Though we find the longline method of fishing successful for sampling yellowfin, only an occasional skipjack is taken by this gear; however, our studies of tuna eggs and larvae convince us that, in addition to the abundant yellowfin, skipjack are present in even greater numbers.

We are now encouraging the development of a commercial fishery. This past spring two West Coast fishing boats took 210 tons of yellowfin tuna from the Line Islands region near the Equator while using the longline method of fishing. At this writing [August 1954] three more Pacific Northwest boats are longline fishing in that region. Here, the discovery and the early exploration of these fishing grounds are nearing an end and the birth of a new fishery is in progress. The success or failure of this new fishery will depend on whether or not American fishermen can profitably harvest the tuna in the new area while using an unfamiliar type of gear, the Japanese longline. The gap between the completion of successful research and the firm establishment of a profitable commercial fishery is difficult to bridge; it will be interesting to see whether the central Pacific tuna fishery will provide one of the rare examples where this transition has been successfully effected.

Although the potential yield from this newly discovered resource is unknown, a comparison of the area of this vast belt

along the Equator with the area used by the present American fishery off Mexico and central America (which supports a $125,000,000 industry) indicates a likelihood that full utilization of the tunas from the central Pacific would produce a like amount.

We believe that there are other regions in the tropical and subtropical Pacific Ocean which, because of unique oceanographic conditions, will prove unusually productive of fish. For example, islands jutting up from the bottom of the ocean and interrupting the flow of major currents apparently cause enrichment of surrounding surface waters. Also, north of the Hawaiian Islands at the boundary between the easterly-flowing North Pacific Drift and the westerly-flowing North Equatorial Current is a region of turbulence and eddies which shows promise of prodigious biological productivity. Investigations are now under way to find and chart these favorable environments and to evaluate their potential fishery resources.

U.S. DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
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CONSTRUCTION DETAILS OF IMPROVED TUNA LONG-LINE GEAR USED BY PACIFIC OCEANIC FISHERY INVESTIGATIONS

By Herbert J. Mann*

CONTENTS

	Page		Page
General Description	2	Hauling	6
Fabrication of the Gear	3	Materials Used to Make up Gear	8
Assembling Lines for Setting	5	Discussion	9
Setting	6	Literature Cited	10

This report is a description of the latest type of fiber long-line gear now being used by Pacific Oceanic Fishery Investigations (POFI) to capture tunas in the central Pacific. It is a revision of an earlier report (Niska 1953) and contains a complete description of the gear and its use, with particular attention to changes made since the earlier report was issued.

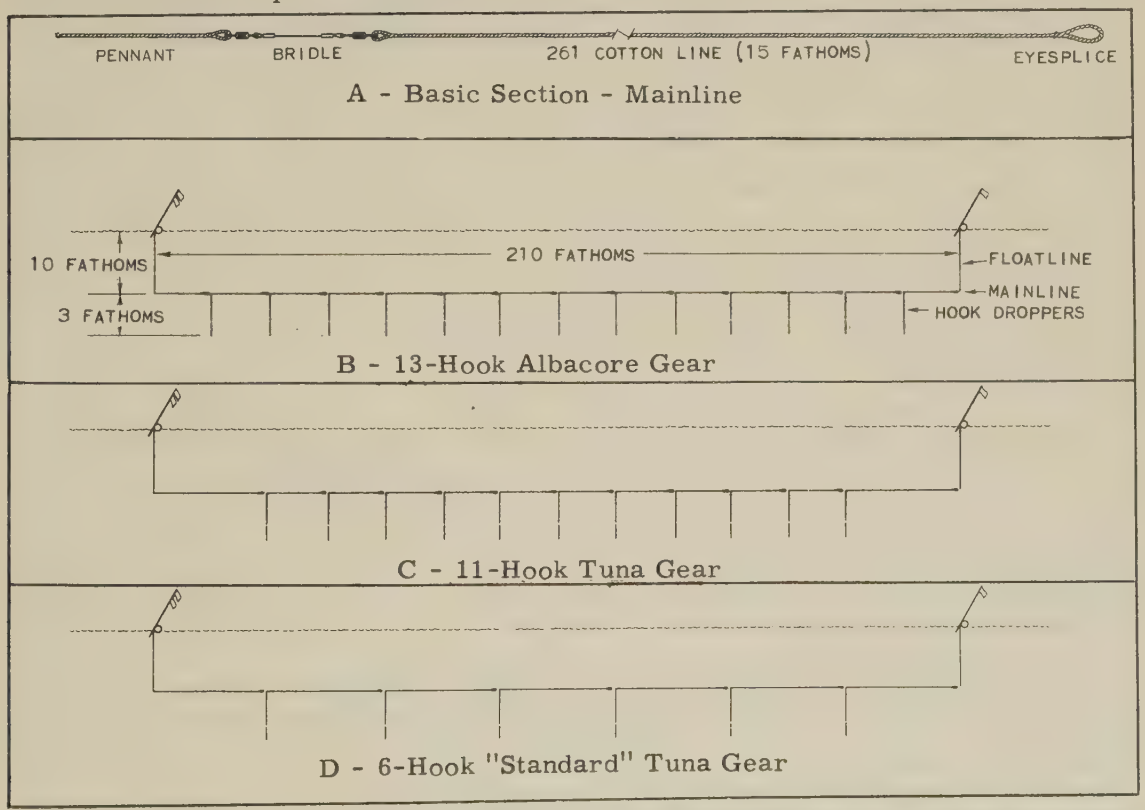

Fig. 1 - Three types of POFI long-line gear, and the basic component of their mainlines. A - 15-fathom section used in making up mainlines. B - 13-hook basket (unit) designed for albacore fishing. C - 11-hook basket used in fishing for larger tunas, such as yellowfin and big-eyed tuna. D - 6-hook "Standard" basket used in most of POFI's experimental fishing.

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The original POFI tuna long-line gear was derived from designs employed by Japanese and Hawaiian fishermen. A general discussion of the history, fabrication, and operation of such gear is included in reports by Shapiro (1950), June (1950), Murphy and Shomura (1953), and Niska (1953). So many changes have been made in the design of the gear since 1953 that a new account is necessary to acquaint the fishing industry with the successful innovations. It should be noted that the dimensions and basic design of the gear have not been changed; however, several modifications have increased the speed of setting and hauling and have resulted in greater flexibility. Each of these changes has been tested in the field under controlled conditions. The results of these field tests are discussed in Murphy and Shomura (1953), and Shomura and Murphy.1/

GENERAL DESCRIPTION

The basic unit of the long line is the "basket" or "skate" (fig. 1), a 210-fathom length of mainline with droppers and buoyline, stored in a canvas skid or a bamboo basket. In the POFI experimental fishing operations about 60 such baskets are joined together to make a day's set. Since they are identical in design, plans of only one basket are shown in the diagram.

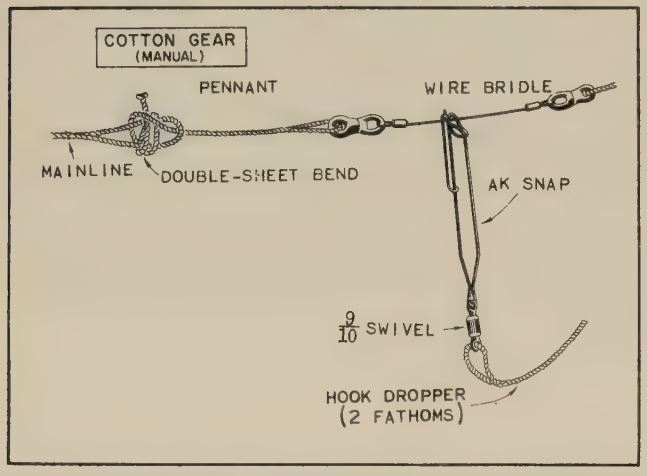

Fig. 2 - Method of joining two mainline sections, and details of wire bridle and branch-line attachment.

MAINLINE: The mainline of each basket is made up of 14 similar sections, each consisting of a 15-fathom length of cotton line with wire bridle and a short pennant or "pigtail" (fig. 1A). These sections are knotted together using the double sheet bend shown in figure 2. The principal advantage of such a system is that, since each section bears a one-hook dropper, various numbers of hooks from 1 to 13 per basket can be fished without resplicing or reworking the mainline. Another advantage of joining the sections with knots is that tangled sections of mainline may be removed without delay and set aside as the gear comes aboard.

DROPPER ATTACHMENT: Each basic mainline section has a swiveled wire bridle for the attachment of droppers (fig. 2). This fitting has eliminated one of the most troublesome defects of the old gear. Formerly, mainline sections were made up with eyesplices at each end and were joined by knotting the loops together; droppers were attached by clipping an AK snap into one eyesplice. When the gear was hauled, the incoming mainline rotated because of the twist developed by the lay of the line and droppers were wound around it. The resulting tangles seriously delayed recovery of the gear.

The wire-bridle system has virtually eliminated this type of tangling. Droppers are now joined to the mainline by clipping the AK snap over the wire bridle. Since there is ample clearance between wire and snap, the mainline can rotate freely without affecting the dropper. The swivels at the ends of the bridle also help to reduce the twisting effect caused by the lay of the line.

HOOK DROPPERS: The 10-fathom and 5-fathom hook droppers, or branch lines (gangions), have been cut to 3 fathoms (over-all length, including leader) and the

1/ Long-line fishing for deep-swimming tunas in the central Pacific, 1953. U. S. Fish and Wildlife Service, Spec. Sci. Rep.: Fish. No. 157.

costly sekiyama[2/] has been eliminated as unnecessary. The 3-fathom length marks the shortest length that can be efficiently fished; 2-fathom droppers have been tried but proved harder to coil and were more hazardous in setting and hauling than the 3-fathom type. Construction of droppers is shown in figures 2 and 3.

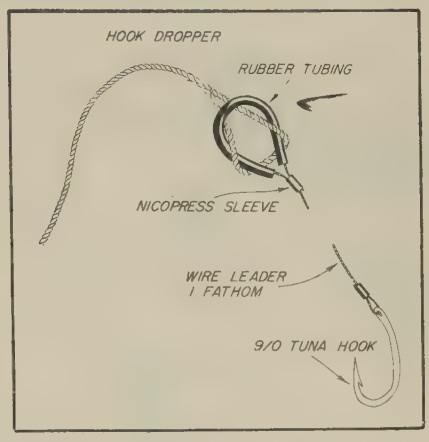

Fig. 3 - Details of branch line, leader, and hook assembly.

FLOATLINES: Floatlines, which join buoys and mainline, are made up of 5-fathom sections. The sections have an eyesplice at one end so that they may be joined by a double sheet bend. The depth of the mainline is varied by adding or removing sections without cutting or splicing line. Floatlines are joined to the mainline by the AK snap and knot shown in figure 4. Attempts have been made to use a wire bridle similar to the one used for the attachment for hook droppers, but the snaps opened up and this arrangement was discarded.

BUOY LIGHTS: Hauling operations may sometimes last until after dark, so battery-powered buoy lights are usually attached to the end poles and to several intermediate poles of the set. A typical light installation is shown in figure 5.

LONG-LINE CONTAINER: POFI long-line gear was originally stored in the standard bamboo basket commonly used in the Hawaiian and Japanese fisheries. This method of stowage was objectionable because of the space taken up by the empty baskets. POFI now stores gear in canvas skids similar to those used in the halibut long-line fishery (fig. 6).

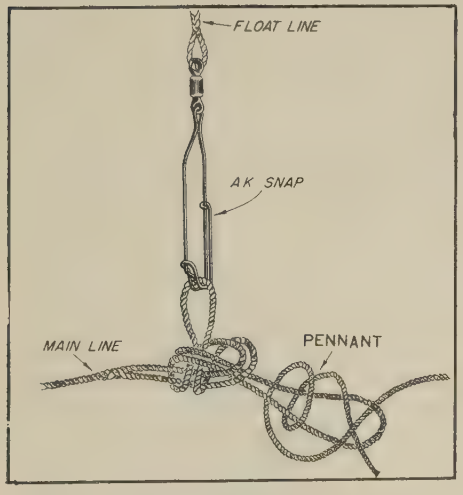

Fig. 4 - Attachment of floatline to mainline at juncture of two skates.

FABRICATION OF THE GEAR

PREPARATION OF LINE: Mainline, floatlines, and hook droppers are made of best grade hard-laid 261-thread cotton twine. Since the gear remains wet for long periods at sea, the line must be treated with some type of preservative. A commercial copper-base preservative is commonly used by POFI. Skeins of new line are cold-dipped for a period of three minutes in a full-strength solution and are then dried in the shade.

The treated line is then stretched and cut into 15-fathom lengths. To save time, several lines are cut simultaneously in the following fashion: skeins are opened out and placed on vertical reels; the ends of several lines are attached by brass swivels to the rear bumper of a jeep so that the lines can rotate freely to remove kinks; the lines are then unreeled and stretched out over a measured 15-fathom distance and a steady strain of 125 pounds is exerted until kinks are eliminated. A Dillion dynamometer is used to check tension on the lines and prevent overstretching.

MAINLINE: Cut lines are coiled down in sets of 14 pieces each, the number required to make up one skate. These basic mainline sections are then completed by splicing in eyes, wire bridles, and pennants as shown in the diagram (fig. 1A). The end pennant of each basket is made from $\frac{1}{4}$-inch cotton rope rather than 261-thread line and the end eyesplice is lengthened.

2/ Sekiyama or shanawa--a stiff pennant consisting of a linen or wire core served with cotton twine, used by Japanese and Hawaiian fishermen to connect the wire leader to the cotton branch line, and formerly employed in POFI long-lines.

Wire bridles 6 inches long are fashioned from $\frac{5}{64}$-inch 1 x 7 stainless wire rope. No. 2 Seadog swivels are fastened to the wire by means of Nicopress fittings (fig. 2).

HOOK DROPPERS: The construction of hook droppers is shown in figures 2 and 3. Two-fathom lengths of treated 261-thread line are made up with a special snap at the upper end. This snap, a model used by the Northwest trolling boats, is a No. 9/0 Kolstrand AK snap, but is constructed of heavy No. 7 wire and has a jaw opening of $\frac{1}{8}$-inch diameter. It is important that the AK snap be designed to fit the wire bridle with a small clearance, since otherwise the snap is apt to jam against the swivel. The lower end of the dropper terminates in an eyesplice to which is joined hook and leader, as shown in figure 3.

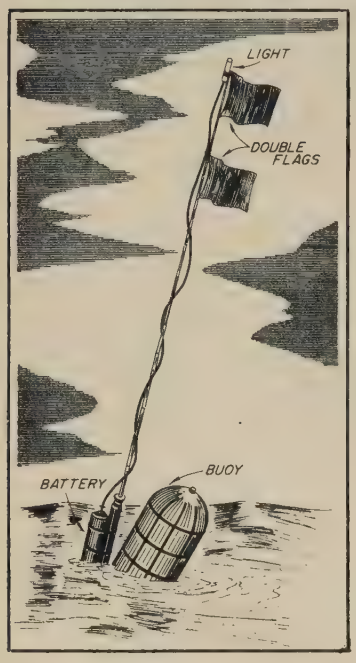

Fig. 5 - Battery-powered light buoy.

The leaders are fashioned of 6-foot lengths of .066-inch diameter right lay 1 x 7 galvanized plow-steel wire. Galvanized wire is used rather than stainless steel since it reduces the electrolytic action between hook and leader. Stainless steel leaders destroy hook plating in a very short time. A 3-inch loop in the end of the leader is fitted with a section of $\frac{3}{8}$-inch O.D. x $\frac{1}{8}$-inch I.D. industrial rubber tubing, which serves to prevent chafe. A 9/0 or 8/0 tuna hook is attached to the leader by a 1-inch loop fastened with a Nicopress sleeve (fig. 3). It should be noted that the hook is of a special shape, with a bent shank which allows the bait to hang in line with the leader. Such a hook has better fish-holding qualities than the conventional straight-shanked models.

FLOATLINES: Floatlines are made from 5-fathom lengths of 261-thread line. An AK snap is spliced into one end and an eye formed in the other. Mainline and floatlines are joined as shown in figure 4.

FLOATS: Floats used in the Hawaiian fishing industry include glass balls, wood billets, and metal tanks of various sizes. The floats used by POFI are made from surplus stainless-steel oxygen tanks of 2,100 cubic inches internal volume (figs. 7 and 8). These are fitted with a $\frac{3}{8}$-inch galvanized eye bolt for attachment of a floatline. Since the tank comes provided with a $\frac{1}{4}$-inch outlet, it is necessary to reduce this opening by fitting a $\frac{1}{8}$-inch to $\frac{1}{4}$-inch hex-head pipe bushing between tank and bolt. An 8-inch grommet of $\frac{3}{8}$-inch diameter manila rope is spliced into the eye for attachment of the bamboo pole. A $\frac{3}{8}$-inch stainless-steel thimble protects the grommet against chafe (fig. 8). Buoys are painted a bright orange for greater visibility.

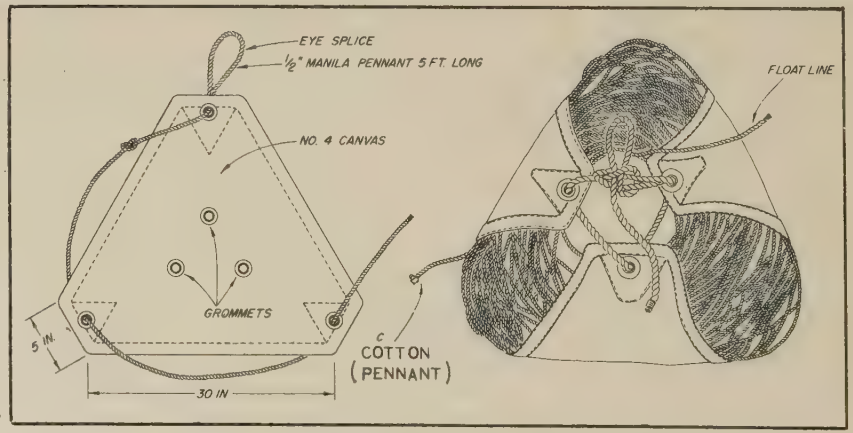

Fig. 6 - Canvas skid for stowing long-line skates.

FLAGPOLES: Alternate buoys have poles with flags to serve as markers in locating gear (fig. 7). Poles are select bamboo 14 to 16 feet in length with a butt diameter of $1\frac{1}{4}$ inches to $1\frac{1}{2}$ inches and a tip diameter of about $\frac{5}{8}$-inch.

The poles are protected from chafing on the floats by a 15-inch section of heavy air hose. Split lengths of hose are clamped on the pole with a lower end 6 feet 6 inches from the butt. Clamps are $\frac{3}{8}$-inch Band-It straps secured with the buckles fixed over the cut. This attachment is made so that the buckles are turned away from the buoy, presenting only the smooth band to minimize chafing.

A 5-inch loop of $\frac{3}{8}$-inch manila line is fastened at the bottom of the pole for attaching the floatline. This loop is held in place as follows: a rosette is made in each end of the line and a Band-It strap is clamped midway on the rosette, which serves as a cushion preventing the loop from slipping under the band. The ridge at the lower joint of the pole tends to prevent the loop and band from slipping off the butt of the flagpole.

The float is tied to the flagpole by a 4-foot lanyard of $\frac{3}{8}$-inch manila line, which is secured to the flagpole just below the chafing gear. The end of the lanyard next to the pole ends in an eyesplice, as shown in figure 8. A safety line of 261-thread cotton line runs from this eye to the bottom of the pole, where it is made fast to the manila loop. If the bamboo pole breaks during fishing operations, the safety line prevents loss of buoy and floatline. On setting the gear, the free end of the lanyard is joined to the grommet of the float by a reverse sheet bend with bow (fig. 8).

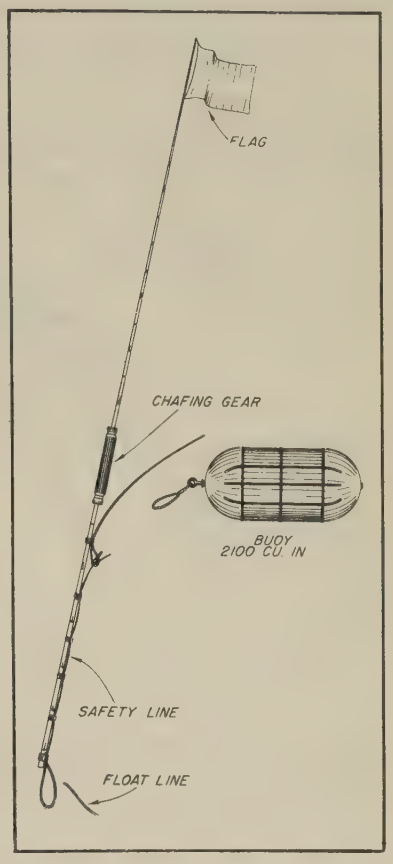

Fig. 7 - Complete flag and float assembly, showing chafing gear.

Bunting flags are attached to the top of the flagpoles by waxed, doubled, cotton-thread ties fixed to the corners of the flags. POFI flags are dyed a bright orange since this color seems to show up well under all sea conditions. The size of flags has been increased to $1\frac{1}{2}$ square feet in an effort to increase the range of visibility. Double flags are used to mark various portions of the set such as the ends and center.

CANVAS SKID: To make the skid (fig. 6), No. 4 canvas duck is cut in the shape of an equilateral triangle 45 inches on a side. Corners are turned in with No. 5 grommets punched in the center. A $\frac{3}{8}$-inch manila becket, 60 inches long, is laced through the grommets. A 3-inch loop is spliced on one end, and the standing end is securely whipped. The loop is secured on one grommet by an overhand knot immediately behind the eyesplice. With the line in place the standing end is laced through the other two grommets and passed through the eye to form a bight. A slip knot finally secures the line. Skids have brass grommets in the bottom to provide proper drainage and ventilation of wet line.

ASSEMBLING LINES FOR SETTING

Prior to setting, mainline and branch lines are assembled and the gear is carefully coiled down on the skid. The bottom end pennant is left exposed for joining to

the next basket (fig. 6). Hook-dropper coils are made up smaller than mainline coils and are secured by hooking the tuna hook into the rubber chafing gear on the wire leader. The floatline is coiled down on top of the pile, the skid is then tied up, and the gear is ready for setting.

SETTING

The gear is laid in a straight line and in a direction relative to the wind and sea which will make it easy to haul the line. Hauling is easiest when the wind blows from about 30° off the bow on the side of the line hauler. Therefore, gear is usually laid with the wind about 30° off the stern opposite from the line hauler. When course is reversed to pick up the gear, if no wind shift has occurred, the winch side will be the weather side and wind and sea will be broad on the bow.

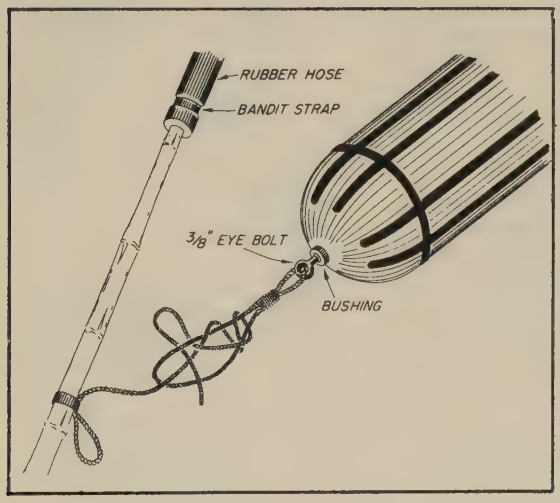

Fig. 8 - Details of attachment of float to flagpole.

When setting close to islands or banks, or in an area where currents are known to be strong, the direction of set must be chosen with care. Setting across a current boundary is avoided as the mainline is apt to part with the strain. Particular care must be taken in setting in shoal water close to land where strong surface currents may sweep the gear into shallow water before it can be recovered.

Setting is usually done from a "setting table" on the stern of the vessel. This is a wooden bench large enough to hold several skates of gear and the bait needed for the set. In setting (1) the vessel is put on the desired course; (2) floatline, buoy, and flagpole (usually with double flag) are joined to the first basket and pitched overboard; (3) one fisherman pays out coils of mainline while others uncoil droppers and bait hooks.

The amount of slack in the mainline, and consequently the fishing depth of the gear, is controlled by the fisherman throwing out the mainline coils. These may be thrown out rapidly to give a "slack set" which fishes at a comparatively great depth, or they may be held until the line is stretched out taut by the vessel, which results in a comparatively shallow fishing depth. A slack set may also be accomplished by steering a zigzag course while paying out the line.

HAULING

LONG-LINE HAULER: The gear is hauled with a Japanese line hauler of the type shown in figure 9. Such a winch is used in preference to an ordinary gurdy because it coils down the mainline automatically with little attention from the winch operator.

The coiling of the line is accomplished by the hauling head shown at the top of the winch. This assembly consists of a split sheave (A) grooved to fit the diameter of the line to be hauled; a wide center wheel with replaceable rubber collar (B); and a movable brass idler (C) controlled by the lever at the left. All three units are connected by a gear train which synchronizes them when they are turned by the drive shaft in the base of the winch.

In hauling, the incoming line is led under the grooved sheave, then over the center wheel and between it and the brass idler. The grooved sheave grips the line

and the idler squeezes it against the rubber collar giving friction to pull the line in as the sheaves rotate.

The line is deflected downward by the brass plate (D) to a platform below, where it coils itself. The size of the coil is dependent upon the distance between plate and platform, so it is necessary to adjust the height of the latter with care.

The hauling head is turned by the drive shaft at the bottom of the winch through a multiplate oil-bathed disc clutch located in the base of the winch. The foot-operated clutch control is mounted near the ship's bulwark close to the overside roller so that the winch operator can see the incoming branch lines easily. The clutch control is so arranged that the winch operates continuously unless the clutch pedal is depressed.

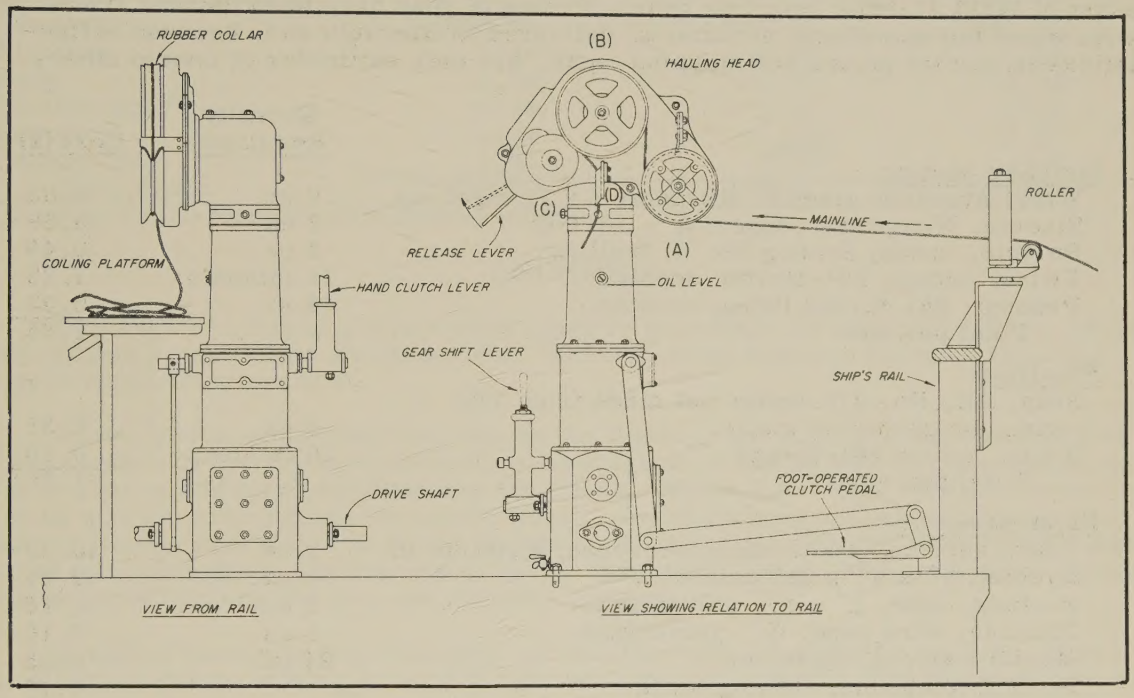

Fig. 9 - Japanese long-line hauler.

The gear-shift lever shown at the lower left controls the hauling speed. With a drive shaft input speed of 300 r.p.m., high gear yields a line speed of about 1,000 ft./min., low gear a speed of 500 ft./min.

Hawaiian and Japanese fishing vessels frequently drive line haulers with a line shaft take-off from the main engine. On POFI vessels an electric drive (3 hp. waterproof motor d.c. 1,725 r.p.m.) and a 5:1 gear reduction, or a hydraulic drive (7.5 hp. 35.8 gal./min. pump at 1,200 r.p.m.) are used to power haulers.

HAULING PROCEDURE: Hauling operations on Japanese vessels have been described by Shapiro (1950) and Shimada (1951). On POFI vessels the mainline is brought aboard, led through the overside rollers, and fed into the line hauler. The winch is controlled by the clutch operator, who stands at the rail and stops the winch by the foot control to detach branch lines. The fisherman tending and coiling line can also stop the hauling by pulling back on the idler lever, thus releasing tension on the line. Floatlines and hook droppers are detached as they reach the overside roller. The buoys and flagpoles are untied and stowed, and the floatlines and droppers are coiled by hand. As the mainline coils under the line hauler, floatlines and

droppers previously coiled by hand are reattached in the proper places so that the "basket" is ready for use the following day.

If the gear is not to be used for some time, as for example, when the vessel changes fishing grounds, droppers are removed from the mainline and are stowed separately. If practicable, hooks and leaders are removed from the droppers, for if assembled gear is stored wet for long periods, metallic components react with the damp line to cause weak spots. Gear is dried whenever possible, but exposure to direct sunlight is avoided.

MATERIALS USED TO MAKE UP GEAR

The following list of materials contains the items necessary to make up one basket of POFI 11-hook long-line gear. Prices of gear have been derived from Government bid quotations on material delivered in Honolulu and, because of fluctuations in market prices and shipping costs, are only estimates of cost to others.

Item	Quantity Required	Cost ($)
1. Mainline Section:		
Wire, stainless steel $\frac{5}{64}$" diameter 1 x 7, right lay	6 in.	0.03
Sleeves, Nicopress copper, $\frac{1}{16}$", 18-1-C	2 ea.	0.08
Swivels, brass, Seadog No. 2, trolling	2 ea.	0.46
Twine, cotton, 261-thread, treated	15 fathoms	1.25
Pennant, 261-thread twine, treated	24 in.	0.03
Total per unit		1.85
2. Floatline:		
Snap, AK, No. 9/0 design but made from 7/0 wire, brass barrel swivel	1 ea.	0.35
Twine, cotton 261-thread	10 fathoms	0.90
Total per unit		1.25
3. Float Assembly:		
Tank, surplus, stainless steel oxygen, 2,100 cu. in.	1 ea.	10.40
Eyebolt, $\frac{3}{8}$" x $4\frac{1}{2}$", galvanized	1 ea.	0.55
Bushing, pipe, $\frac{1}{4}$" - $\frac{1}{8}$", galvanized	1 ea.	0.16
Thimble, wire rope, $\frac{3}{8}$", galvanized	1 ea.	0.10
Manila rope, $\frac{3}{8}$" diameter	24 in.	0.05
Sealing compound, lashing twine	-	0.10
Paint, Westinghouse, orange enamel	$\frac{1}{2}$ pt.	0.40
Total per unit		11.76
4. Bamboo Pole Assembly:		
Pole, bamboo, 14" long x $1\frac{1}{2}$" at base	1 ea.	0.70
Flag, bunting, 14" x 18", orange	1 ea.	0.24
Hose, air, surplus, heavy	14 in.	0.80
Strapping, Band-It, $\frac{3}{8}$" width	18 in.	0.09
Buckles, Band-It, $\frac{3}{8}$" width	3 ea.	0.18
Rope, Manila, $\frac{3}{8}$" diameter	6 ft.	0.15
Total per unit		2.16
5. Hook Dropper:		
Snap, AK, 9/0 formed of 7/0 wire with brass barrel swivel	1 ea.	0.35
Twine, cotton, 261-thread	12 ft.	0.18
Tubing, rubber, black industrial, $\frac{3}{8}$" O.D. x $\frac{1}{8}$" I.D.	6 in.	0.08
Sleeves, Nicopress, $\frac{1}{16}$"	2 ea.	0.08
Wire rope, leader, .066" dia. 1 x 7 right lay plow steel, galvanized	6 ft.	0.06
Hook, 9/0 or 8/0 mustad flatted tinned, tuna	1 ea.	0.18
Total per unit		0.93

Item	Quantity Required	Cost ($)
6. Skid:		
Canvas, No. 4, triangle 45" each side	1 ea.	1.03
Manila rope, ½" diameter	60 in.	0.20
Spur grommet, heavy, brass	6 ea.	0.12
Total per unit		1.35

Since POFI gear can be assembled so as to fish different numbers of hook droppers, the cost of individual baskets varies according to the type of gear used. Costs of typical gear assemblies are shown below:

Components	6-Hook "Standard"	11-Hook Tuna	13-Hook Albacore
Maineline--14 sections basket	$25.90	$25.90	$25.90
Floatline	1.25	1.25	1.25
Buoy	11.76	11.76	11.76
Bamboo pole 1/	2.16	2.16	2.16
Droppers	5.58	10.23	12.09
Canvas skid	1.35	1.35	1.35
Total Skate	$48.00	$52.65	$54.51

1/ Bamboo poles are usually attached to alternate buoys only.

DISCUSSION

The greatest defect of the present gear is the relatively short life of the cotton twine used for mainline and droppers. Three factors combine to cause this relatively rapid deterioration.

First, due to conditions inherent in the fishery, the line is often overstrained. This method of fishing is necessarily nonselective as far as catch is concerned, and large sharks and marlins often take the hooks. Heavy fish chafe the line and sometimes stretch gear beyond its elastic limit. Overstraining of the line also occurs during fishing operations in rough weather, for it is then difficult to keep the vessel close up to the gear. As the vessel drifts away from the set, the mainline is sometimes parted before the ship can recover position.

A second factor is wear and tear on the line during hauling operations. Some abrasion is due to chafing of hooked fish when droppers tangle with the mainline, but most of the damage is done by wear on the line as it passes over the rollers and through the line hauler. Wear is especially evident where swivels are inserted in the line.

Finally, the line deteriorates because proper care of the gear is extremely difficult. While on the fishing grounds, gear is set during the day and stored damp at night in the skids; it is frequently stored damp for several days at a time while the vessel changes fishing grounds. Under such conditions cotton line loses strength rapidly. It has been possible to make some progress in methods of preserving gear. For instance, POFI gear treated with copper-naphthenate preservatives now lasts about twice as long as the tan bark-treated line used in the Hawaiian fishery. Tarred line used exclusively by the industry in Japan and to some extent in Hawaii is now being tested but has not yet been evaluated.

It should be pointed out that the gear described in this report has not been designed primarily for commercial use. Rather, an effort has been made to develop a type of gear which would be extremely flexible and which could be changed rapidly for various types of experimental fishing. During the evolution of this gear, several design limits appear to have been reached. Thirteen hooks per basket appear to be the maximum number practicable with this type of gear. As many as 21 hooks per

basket have been fished, but the net result was a slowing down and a reduction of efficiency in both setting and recovery of the gear. Hook droppers also have been shortened to their minimum length. Thus, it is anticipated that the general design of the gear may remain unchanged for some time but that futher improvements may well be made in the speed with which the gear is operated and the durability of the materials from which it is constructed.

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